
ACHINE DESIGN
une 1951
Engin
In This Issue:
STRAIGHT-LINE MECHANISMS
EVALUATING ENGINEERS
SEALS FOR ABRASIVE FLUIDS
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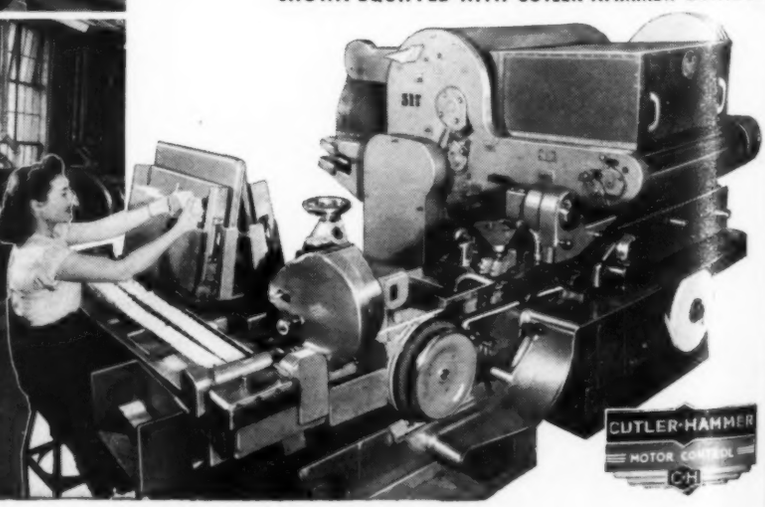
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MACHINE DESIGN

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

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Dunkirk 2-1758
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Published by
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Also publisher of
Steel • Foundry • New Equipment Digest

Published on the seventh of each month. Subscription in the United States and possessions, Canada, Cuba, Mexico, Central and South America: One year $10. Single copies, $1.00. Other countries one year, $15.

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Acceptance under Act of June 5, 1934. Authorized July 20, 1934.

Over the Board



Problems

MACHINE DESIGN's research staff has been busy over the last several months charting trends in the relative attention being given to various engineering design problems. We have asked you to tell us what particular phases of design were most important to you at the time you received our questionnaires. The results are interesting.

In October 1950 the four problems being given most attention were, in this order: Reduced cost; production methods; improved appearance; and materials selection. Today materials selection has nosed into second place, with reduced cost still at the head of the list. Another problem which is receiving much greater attention today than in October is weight reduction, which jumped from tenth to fifth place.

To those readers who took the time to answer our questionnaires, many thanks. Your co-operation is proving most helpful to us in planning editorial coverage that is geared to your needs. Watch for our forthcoming August issue!

This Month's Cover

Remember what Robert Burns said about the best-laid plans of mice and men? Well, we like our cover pictures to tie in with some feature of the same issue and that was our plan in preparing the cover you see this month. The picture was intended to accompany Douglas Rumsey's article "Redesigned for Higher Speed." But the April Drives and Controls issue in which the article appeared as the lead feature already had a special art cover. So it is that the cover you see in June illustrates an article which appeared in April. It shows an American Machine & Foundry Co. breadwrapper redesigned for high speed. Design problems included development of smoother acting mechanisms to prevent throwing sliced bread around the bakery. The answer was found in the use of planetary Geneva mechanisms and harmonic cams to reduce peak loads.



They Say . . .

Often you will find at the ends of articles in MACHINE DESIGN pithy quotations under the heading *They Say . . .* These sayings, we hope, inspire and entertain our readers in addition to utilizing to good advantage the remaining space on the page. On Page 156 of the April issue we quoted E. H. Reed on the subject of conferences, which reminded one of our readers, Paul Sebring of the Ordnance Research Laboratory at Pennsylvania State College, of this definition: A conference is a gathering of very important men who singly can do nothing, but together can decide that nothing can be done.

High-Power Chain

Engineering analysis of standard machine components can pay off in a big way. How such an analysis has broadened the field of application of the prosaic chain drive is told in the brief article beginning on Page 139. Ingenuity plus mathematics plus plain horsesense teamed up to produce a power transmission chain with capacities up to 5000 hp.

Crossed Shafts Again

On this page in the April issue we outlined the problem of connecting nonparallel shafts which do not intersect. One of our readers had experienced difficulty with excessive wear when using helical gears to transmit 50 hp. Several readers have written in to suggest the use of hypoid gears. Another reader, Norman W. Taylor, offers a solution which may appear to dodge the issue but which is eminently practical.

Norm suggests alternative ways of handling the problem, depending on conditions. First, if the shafts are reasonably close at their nearest point, place a countershaft between them, parallel to one and in the plane of the other. Couple the two parallel shafts by spur or herringbone gears and the two intersecting shafts by bevel gears. Second, if the shafts are remote at their nearest points, place a shaft perpendicular to one shaft and in the plane of the other. Each intersection then can be connected by bevel gears.

Extra Copies of Articles

Our latest tabulation of your requests for personal copies of MACHINE DESIGN articles shows that an increasing number of readers are taking advantage of our return postcard service. The response to individual articles varies all over the lot, some articles pulling only a nominal number of requests and others, hundreds. For the February engineering data sheet on stress concentration, for example, there were more than twice as many requests as the next highest on the list, completely exhausting our supply before all requests were filled. In March, however, we rang the bell with three articles which each pulled about an equal number of requests: "Determining Practical Tolerances," by Wayne A. Ring; "Mechanical Properties of Metals," by H. W. Gillett; and the engineering data sheet on stress concentration by R. E. Peterson.

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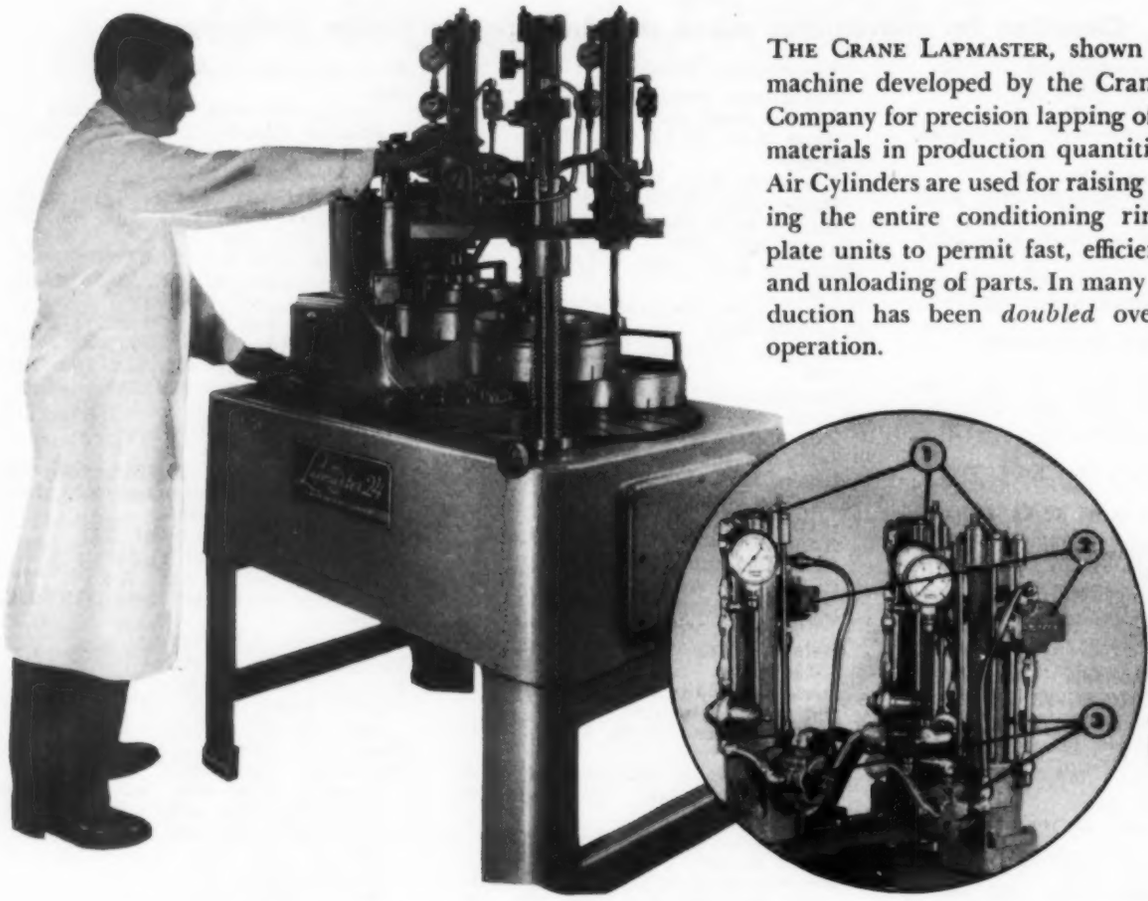
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IN THIS LAPPING MACHINE

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TOPICS

ULTRASONIC VIBRATION is the secret of a new process for machining such hard materials as carbides, borides, tool steel, glass, and gems. Vibrating 27,000 times per second, a blunt tool shaped like the cut to be made is held against the work. Actual cutting is performed by an abrasive such as boron carbide which is carried under the tool in a liquid suspension. According to the Cavitron Corp., manufacturer of the equipment, holes and recesses of any arbitrary shape ranging in diameter from 0.007 to 2 inches can be cut with a tolerance of 0.002-inch. Material is not heated by the cutting action and is not affected metallurgically.

MATERIALS HANDLING improvements can increase America's industrial capacity by a minimum of 10 per cent, according to a recent statement by E. F. Twyman of Yale and Towne. He cited operational tests with the U. S. Post Office on speeding parcel post car loading. Mechanized handling cut loading and unloading time as much as 62 per cent.

MAGNESIUM availability was appraised in rather unique terms recently by L. I. Doan, president of Dow Chemical Co. Magnesium is extracted from sea water, which contains about 0.13 per cent of this light metal. If 100 million tons were produced per year, which is about the current rate of steel production, the concentration would have dropped to 0.12 per cent —at the end of a million years.

GLASS-TO-METAL bonding process has been developed by General Electric. Glass and metal areas are painted with a thin layer of titanium hydride and solder is placed on both areas. Vacuum heating at 900 F completes the process. With soft metal solders, glass-to-metal joints can be safely subjected to rapid temperature changes because the solder absorbs the effects of different expansion coefficients.

STATISTICAL CALCULATOR based on principles of geometry quickly gives many of the factors required in engineering applications of statistics. Squares, sums of squares and square roots, commonly required in statistical work, are all performed simultaneously on this slide-rule type device which is manufactured by the Graphic Calculator Co. Additionally, it can be used to find standard deviations, root-mean-squares, correlation coefficients, geometric and harmonic means and regression lines.

FACSIMILE EQUIPMENT under development by the Army Signal Corps provides small front-line photos of newspaper quality anywhere in the world five minutes after the picture is taken. The new models send pictures or maps, scan at from 45 to 180 lines per minute, and provide definition of 96, 200, and 300 lines per inch. In addition, both words and graphic material can be automatically reproduced on a mimeograph stencil, making hundreds of copies available almost immediately.

LIQUID OZONE appears to be a promising fuel for rocket propulsion. According to C. E. Thorp of Armour Research Foundation, the hazard of spontaneous detonation, which has restricted the use of liquid ozone, has been eliminated by "removing certain thermal, mechanical, electrical, and chemical sensitizing influences."

PUMPED STORAGE is being developed as a variation of modern power generation practice, though first used by the Swiss in 1892. It involves the pumping of water from a river, lake or reservoir into a reservoir at greater height. At allotted times the water is allowed to flow back through a turbine which generates electrical power. Surplus power during off-peak periods is thus utilized to make power available for peak periods. For such service Allis-Chalmers reports the development of efficient units consisting of a pump and a motor which, when reversed, serve as turbine and generator.

STATIC FRICTION TESTS of a number of relatively new special lubricants, in combination with various metals, have recently been completed at the National Bureau of Standards. Lowest static friction was shown, in general, by test lubricants containing molybdenum disulfide—closely followed by a mineral lubricating grease, dry molybdenum disulfide, and a fluorinated hydrocarbon with graphite additive.

MACHINE DESIGN
A PENTON PUBLICATION

Engineering Manpower

THE present critical shortage of engineers is no temporary difficulty. Although the Korean mess, with the consequent stepup in defense activities, has greatly intensified the problem, the root causes of the shortage go back much farther than last summer.

Interruption of the normal output of engineering graduates from colleges and universities during World War II created a void which has not yet been adequately filled. At the same time American industry has continued to expand and increase its output of goods and services requiring engineering skill. Thus, with a sizable military production program superimposed on a civilian economy already at an all-time high it is small wonder that engineering manpower is in unprecedented demand.

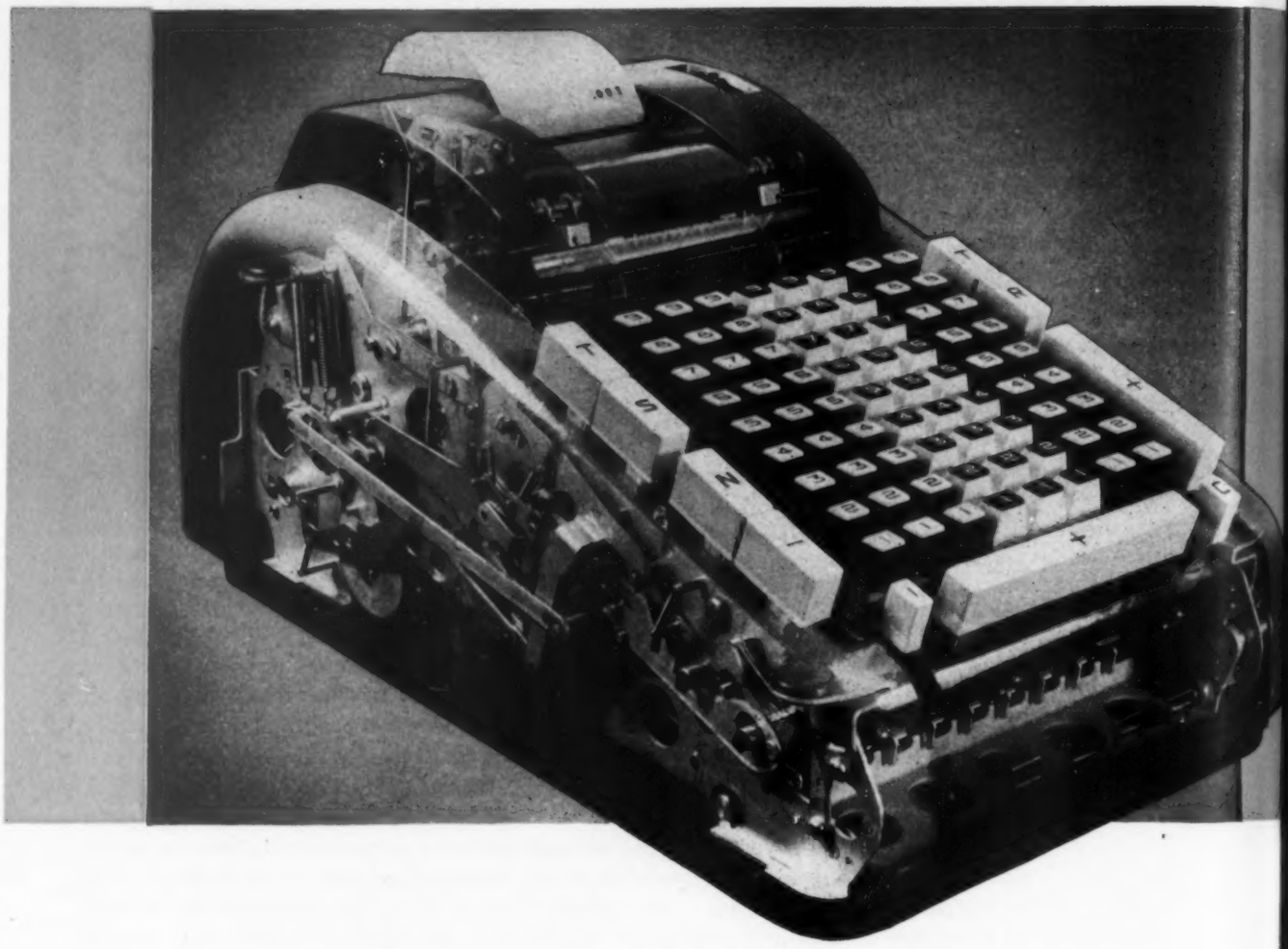
To narrow the gap between supply and demand calls for vision and action on the part of government and of engineering management. Legislation and administration of universal military training and draft laws must be realistic, recognizing that in our present danger all considerations must be secondary to that of building and maintaining unmatched economic and military strength. Any policy which unnecessarily restricts the flow of young engineers through college into industry has the effect of hampering our attainment of that goal.

Engineering management is in a key position to take important action on two fronts. The first is to improve substantially the financial status of engineers. As J. Calvin Brown, ASME president, recently told his society ". . . Some way ought to be found to increase the economic differential between engineering and the crafts. Engineering otherwise stands to lose some of the best minds to other callings. . . ."

The other course of action is to re-examine every phase of engineering activity. By evaluation of the engineering jobs to be done and of the men available to do them, the efficiency of operation can be stepped up, each engineer can work at his maximum skill, and the less exacting tasks can be turned over to less highly trained men. As a result total manpower shortages can be made much less acute. Because this is one approach that is practical and common sense and can be put into action immediately, the editors of MACHINE DESIGN are particularly proud to present in this issue a comprehensive article by Randolph Chaffee on "Evaluating Engineers." This should serve in the coming months and years as a basic reference manual for the efficient administration of engineering manpower, thereby conserving the engineering talent so essential to a strong and prosperous nation.

Colin Carmichael

EDITOR



SPEED is purely a relative term when used with respect to adding machines or office equipment in general. Higher speed simply means greater operator output with no increase in operator fatigue and with no sacrifice in accuracy and dependability. Progress of this sort is exemplified by the adding machine shown in *Fig.* 1. Developments pertaining to both operator facility and mechanical design are reported in this article.

Efforts toward increasing operator output were concentrated along two interrelated channels: (1) Cyclic speed of the machine was increased above the general level prevailing in the industry for machines of comparable classification; (2) the connecting link between the operator and the machine—the keyboard—was designed to allow an operator to take full advantage of the increased cyclic speed.

Keyboard design problems proved to be principally functional. It was determined that highest operator speed could be attained with the system of entering groups of numbers simultaneously into the keyboard. This system was encouraged by condensing the keyboard to allow easy entry over the entire keyboard without exceeding the average operator's hand span.

Also, to provide an easy means of "add" function control, an add bar was provided along the front of the machine. This encouraged simultaneous entry and cycling, and allowed use of the thumb for functional operations. With this group entry and thumb cycling method, it is possible for an operator to maintain her finger grouping during multiplication and division, and merely to move horizontally across the keyboard after taking the required number of cycles in each order.

Condensing the keyboard made design of the key tops a major consideration, *Fig.* 2. To assure against accidental depression of an amount key, the forward surface of the key was made vertical so that unintentional contact with this surface could not cause pressure in a downward direction. The opposite side of the key top was sloped at the steepest possible angle to allow maximum finger clearance. This design makes it virtually impossible to depress two keys simultaneously, unless a finger overlaps two key caps or the hand is held at an abnormal angle.

This functional design of the key top also dictated that the keys be capped in a material of contrasting color to allow easy reading of depressed keys as outlined by the break in the color line. The indentation of the cap on the key top was shaped with a cylindrical surface (axis running front to back) that provides functional touch qualities and, unlike spherical surfaces, throws no glare toward the operator's eyes.

Basically, the internal mechanical elements of an adding machine consist of:

1. The accumulator, a storage medium for information entered into the keyboard

ESIGNING FOR SPEED

In Adding Machines

By R. E. Boyden and K. F. Oldenburg
Chief Engineer *Designer*

Clary Multiplier Corp.
San Gabriel, Calif.

2. The printing unit, which transposes information entered into the keyboard or stored in the accumulator to a permanent record
3. The racks, which transfer information from the keyboard to the accumulator or printing unit, or from the accumulator to the printing unit
4. The controls, which determine operations to be performed, as selected from the keyboard, and the sequence in which they occur.

Since all operations performed by the machine are dependent upon the control mechanisms, these mechanisms had to be fast and dependable. The cam line, *Fig.* 3, which controls all the mechanical functions performed by the machine employs a full 360 degrees driven rotary motion. This rotation allows for the positive control of any mechanism during all or any portion of the machine cycle.

Friction Drive Obviates Locked Keyboard

Racks are driven from the rotary cam line through a semipositive friction drive mechanism. Use of this rack drive enables the machine to do all its addition and subtraction during the first half of the machine cycle. As seen in *Fig.* 4*a*, the racks are moved out through the force exerted by the spring scissors rack drive member, which is detented through the sharp angle on the racks. These forces are sufficient to allow the racks to digitize in the accumulator and position all the printing mechanism. Also, once the



Fig. 1—Adding machine which was designed for higher cyclic speed and easier operation



Fig. 2—Add bar along front of machine permits thumb cyling. Keys are shaped to make depression of two keys with one finger difficult

scissors have been broken by the positioning of the rack against the keystem rack stops, as in *Fig. 4b,* the rack in effect becomes dead. In other words, when a rack has been stopped by a keystem and the scissors member inactivated, even if the stopping keystem were released, the rack would not move. Once the scissors member is broken, the forces of that member against the straight portion of the rack are not sufficient to overcome the force exerted upon the rack by the accumulator gear and its detent. This feature of the rack drive eliminates the necessity of a locked keyboard and all the mechanism such a keyboard entails, and also effectively prevents rebound of the racks which sometimes tends to occur at high machine speeds.

Overthrow Protection Required

With increased machine speeds come the ever-present problems of rebound and overthrow protection. The greatest problems of overthrow are usually encountered in the accumulator which is the heart of any calculating device. This accumulator, *Fig.* 5, usually consists of a series of gears, one for each accumulating order, plus a means of correcting each succeeding higher order whenever the order just below it has been rotated more than nine increments. The means of accomplishing this transfer in the Clary machine can be seen by examining the sketches in *Fig.* 6. Each rack gear order has a transfer conditioning cam which, when any gear is rotated past its tenth increment, will condition a transfer pawl in the next higher order. This transfer pawl may be conditioned positively (down) or negatively (up) depending upon whether the operation being performed is addition or subtraction. *Figs.* 6*a* and 6*b* show the rack gear of one order and the transfer pawl that affects the rack gear of the next highest order.

It is important to notice that during the tenth increment of travel of a rack gear, and as the transfer conditioning cam operates on the transfer pawl, the conditioning may be accomplished over more than 50 per cent of that tenth increment of gear motion. This is possible because, once the transfer pawl has been driven past the critical point, the transfer pawl detent moves the transfer pawl to its fully detented position and the arcs of the transfer conditioning cam and the transfer pawl separate to allow the transfer conditioning cam to clear on further incremental travel. Therefore a maximum of normal clearance is allowable between the transfer conditioning cam and the raised portion of the transfer pawl that it operates upon. This greater normal clearance is the factor that eliminates false conditioning due to overthrow at the higher operating speeds.

During the last half of each machine cycle the rotation of the transfer cam line accomplishes the actual transfer into any accumulator orders that have been conditioned during digitation. *Fig.* 6*c* shows the rack gear upon which the conditioned transfer pawl operates as the transfer cam contacts the transfer pawl linkage, which occurs sequentially from lower to higher orders. The pawl is driven forward into the gear, causing the gear to rotate one increment, at the same time restoring the pawl to its neutral detent position. At the peak of its action, the transfer pawl directly blocks the gear after it has rotated one increment, positively preventing any overthrow due to the transfer action. When the transfer cam leaves the transfer pawl, the pawl returns under the influence of the detent spring to its normal position, as shown in *Fig.* 6*a,* ready for the next digitation cycle.

Positive Transfer Assures Correct Sequence

Since an accumulator normally contains the greatest number of consecutively operated linkages in any machine, the rotating positive transfer cam mechanism assures that each of these linkages will perform its proper function in the correct sequence. Springs within the accumulator are restricted to the functions of detenting and restoring the linkages after they have completed their operations in the proper consecutive order.

In a conditioned order, the transfer function is accomplished by a cam that drives the transfer pawl forward, rotating the gear in that order by one in-

crement. If that order should be in a position where the increment of rotation would require it to adjust its next higher order, it would simultaneously condition that next higher order. However, the transfer cams are spaced radially along the transfer cam line at 22½-degree intervals so that a particular cam does not start to function until the cam in the preceding order has completed its required work. This type of transfer means is known as a positive subsequent sequential transfer mechanism.

Division on an adding machine is usually performed by converting the divisor to its reciprocal and multiplying that reciprocal by the dividend. Another method, used previously only on high-speed calculators, is the multiple subtraction and overdraft of the divisor from the dividend. Because of the high operating speed of the Clary machine, and with the addition of the "dividing eye" feature, the multiple subtraction method becomes a practical means of division on an adding machine. This dividing eye mechanism consists mainly of an automatic machine stop and indicator which function when the accumulator has been overdrawn during the subtraction of the divisor from the dividend. This is accomplished mechanically as illustrated in *Fig.* 7.

The dividend must first be added into the accumulator. The divisor is then entered into the keyboard in a position corresponding to the highest order in the dividend. Depression of the subtract key will then cause the clutch control bar to move in a direction as indicated by the arrow. Through its live tip, motion of the clutch control bar pivots the clutch control dog and releases the clutch, which allows the machine to cycle. As long as the subtract key is held depressed, the machine will continue to cycle and thereby subtract the divisor from the dividend until

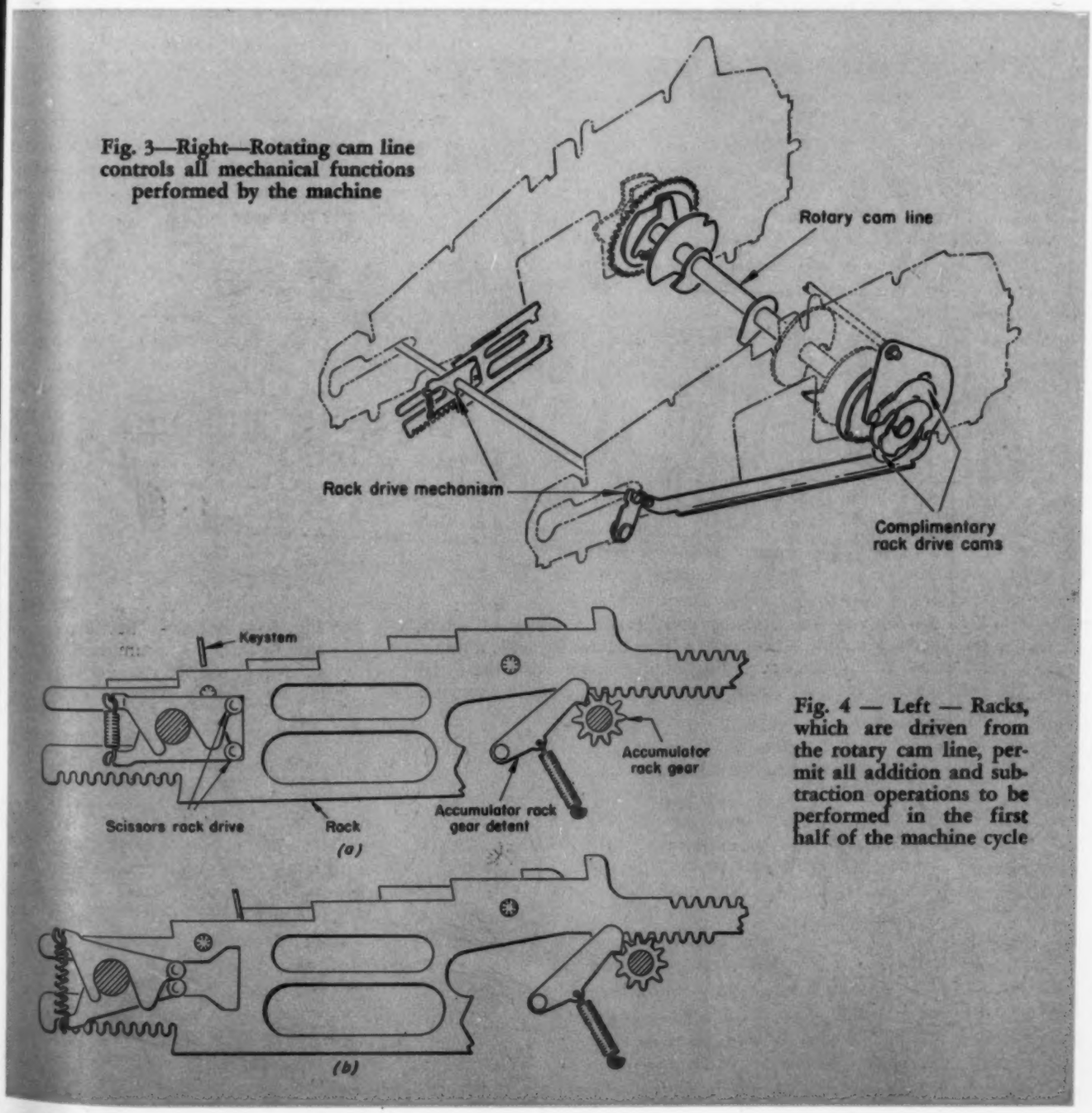


Fig. 3—Right—Rotating cam line controls all mechanical functions performed by the machine

Fig. 4 — Left — Racks, which are driven from the rotary cam line, permit all addition and subtraction operations to be performed in the first half of the machine cycle

such time as the accumulator is overdrawn and a complementary amount appears in the accumulator. When that happens, the accumulator rack gear in the highest accumulator order is moved from zero to nine in a negative direction. As this occurs the transfer conditioning cam of that highest accumulator order acts upon the passover plate and causes it to move to its negatively detented position. This action of the passover plate, through the linkages shown in *Fig.* 7, causes the live tip actuator to cam the live tip up and allows the clutch control dog to come forward under the influence of its spring to a position such that the clutch will be disengaged at the end of that cycle. As the divisor is re-entered once positively, the accumulator and passover plate are restored to the positive side. This operation is then repeated with the divisor moved to its next lower decimal position. When a quotient is obtained with the desired number of decimal positions, the problem is completed and the remainder is indicated.

Although rotary motion is a relatively fast and silent means of mechanism operation, at higher speeds it presents problems of momentum of the rotating members. The easiest way to defeat the problems of momentum is to eliminate or minimize them in the design of the parts involved. Every effort was made to keep the moment arms of rotating high-speed parts as short as possible in this design. This is probably best exemplified in the printer unit of the machine as illustrated in *Fig.* 8. During digitation, the printer dials, through a series of idler gears, are set to the correct print position. The actual printing operation can then be accomplished, in a comparatively short period of the total cycle, by driving the individual levers toward the platen, printing, returning the levers, and restoring them to their normal home position as the racks return to zero.

In this printing mechanism the major mass in the system is the printing dial itself. However, the dial has been designed with a small diameter so that it

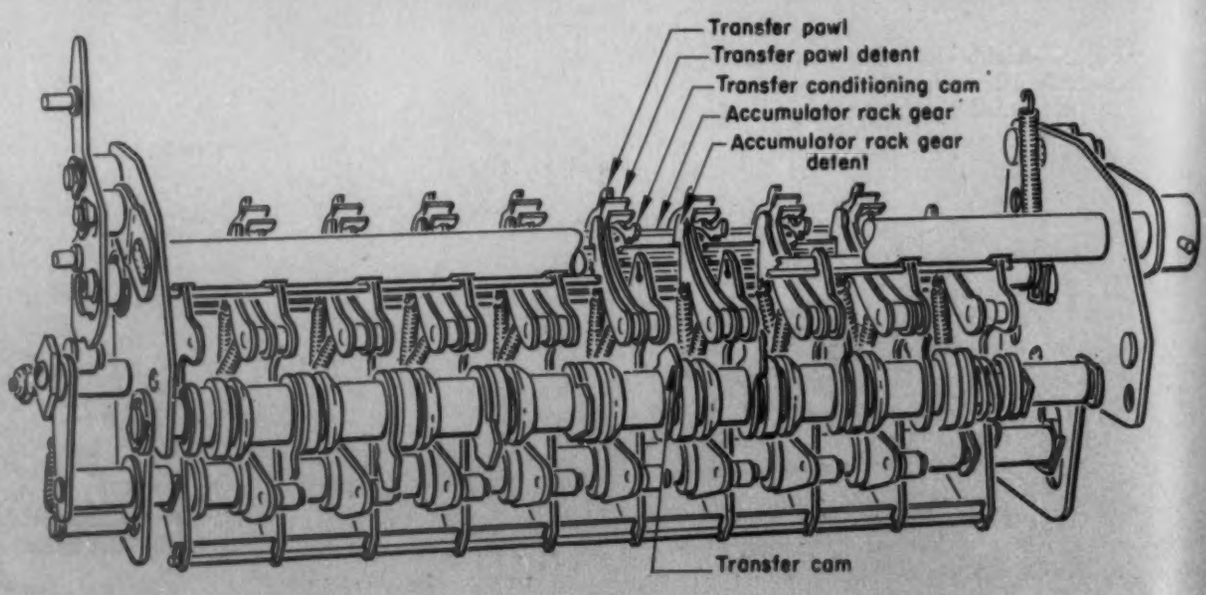
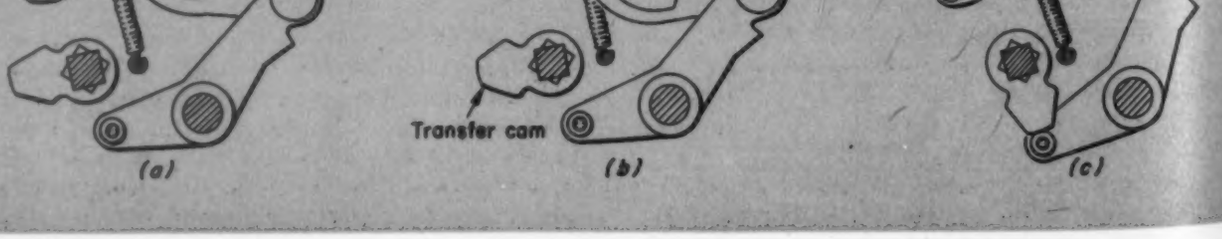


Fig. 5—Above—Accumulator consists of a series of gears, one for each accumulating order. This device includes a method of adjusting each succeeding higher order when the order just below it has rotated more than nine increments

Fig. 6 — Below — Sections through the accumulator showing how the transfer to higher orders is accomplished



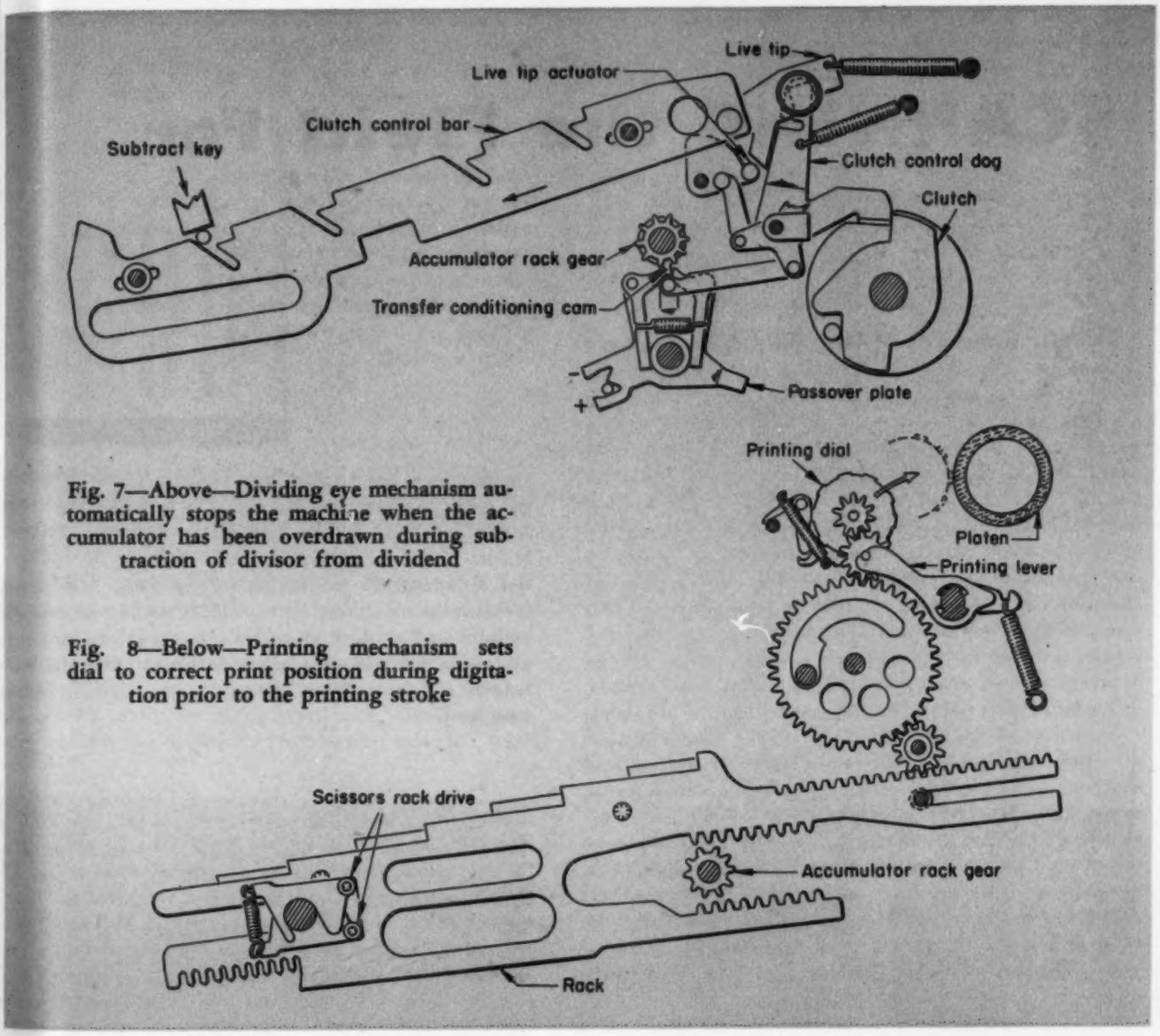


Fig. 7—Above—Dividing eye mechanism automatically stops the machine when the accumulator has been overdrawn during subtraction of divisor from dividend

Fig. 8—Below—Printing mechanism sets dial to correct print position during digitation prior to the printing stroke

presents no momentum problems during positioning which occurs during digitation. On the other hand, this dial becomes the primary mass of the printing lever during the actual printing when high momentum is desirable. Because it is located at the end of the lever arm, a maximum impact force is delivered against the ribbon, paper and platen, and greatly increases the ability of the machine to print multiple copies through carbons.

Wear Reduced by Hardened Friction Surfaces

An inevitable result of higher speed is increased wear in operating parts. This has been reduced by heat treating any parts having friction surfaces, either by carburizing or by the use of cyanide. The resulting hardness is thereby concentrated on the skin of the part, leaving the core soft enough so the part may be adjusted by bending if necessary. However, where parts might strike together with high force, special high carbon steels are used that produce a hard core when heat treated. For bushings or bearings that carry revolving shafts, heat-treated steel is used to standardize materials.

One of the most important features of any product is appearance. A customer's initial reaction is based on what is most obvious. If you tell a person your product operates at high speeds, and its appearance tends to bear you out, one point of selling is easily overcome. This fact was thought to be so important that one of the first things to come out of preliminary design was the general outline of the machine, and limits were then set up on the space allowable for the functional mechanism. As is apparent from *Fig.* 1, efforts were made to eliminate any bulges or bumps or, in general, avoidable changes of contour. The result of this procedure is that a much simpler problem is presented to the artist who may be designing for appearance.

Design efforts also had to be pointed toward ease of assembly and fabrication of parts, low-cost service, complete interchangeability of replacement parts, compactness, and light weight. The machine is composed, as much as possible, of parts fabricated by punch press and automatic screw machine, which can make parts in quantity, accurately and inexpensively.

SCANNING the Field For Ideas

Atomic standards of length are now available to industry through the National Bureau of Standards. They consist of spectroscopic lamps containing a single pure isotope of mercury 198 and will enable any research organization which has auxiliary optical equipment to have an ultimate primary standard of length. Measurement of length involves the optical technique of interferometry whereby the separation of two precisely flat plates is measured in terms of the number of wavelengths between them. Because the number of waves contained in any practical distance is determinable without error and because the wavelength of the light from a single pure isotope of even atomic weight is sharply defined, accuracies of measurement heretofore impossible can be obtained.

Shown below is Dr. W. F. Meggers, under whose direction the lamps are prepared, adjusting an optical system to observe the circular interference fringes of green light from the electrodeless mercury 198 lamp shown in the left foreground. Length measurements based on this interference pattern (background) can be made with an accuracy of one part in 100 million. About one milligram of the mercury is sealed in a glass tube and glows brightly when high-frequency radio waves are applied to it. The wavelength of light emitted is about 21 millionths of an inch and present measurements show that 1,831,249.21 wavelengths equal 1 meter. Life of the lamp appears to be infinite and it is 300 per cent more accurate than the wavelength obtained from cadmium, the present official standard.



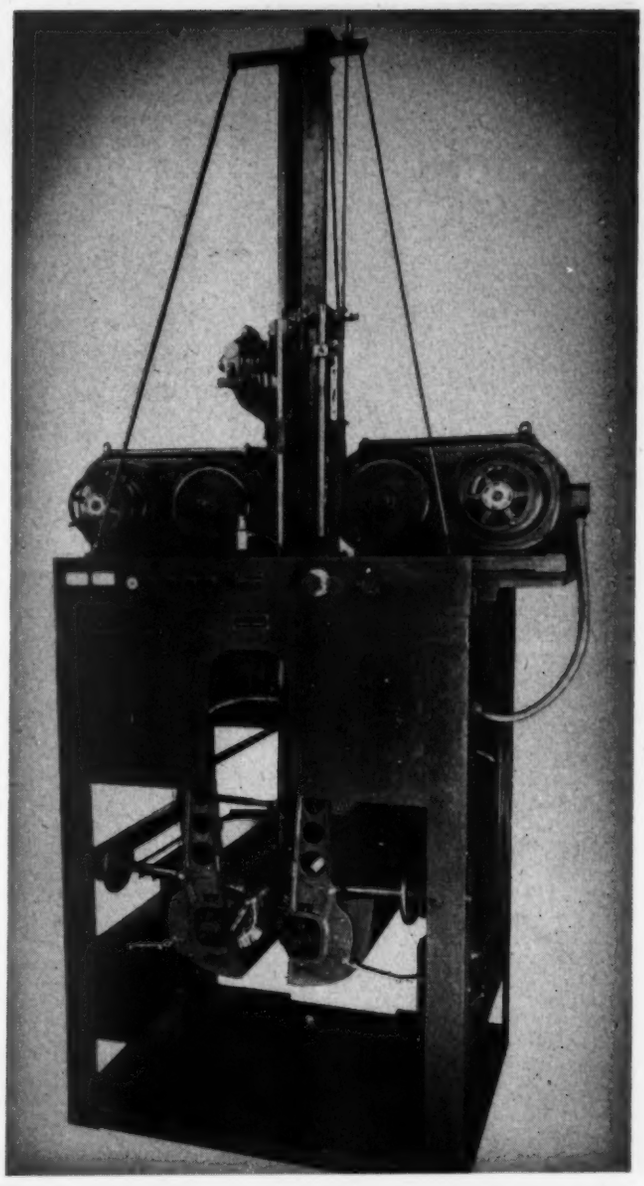
Impact polishing produces mirror finishes quickly and consistently on both sides of a workpiece in the machine illustrated at top of next page. The equipment and method, developed by Nicholas Equipment Co. for polishing cutlery, utilize the principle of removing metal from a surface by bombarding it with abrasive grit resiliently mounted on polishing rolls. These rolls are triple-pleated cotton buffs with grit and glue or buffing compound on their surface. When the rolls are revolved at high speed and brought sufficiently close to the work, centrifugal force brings the abrassive in contact with the work without using high pressure.

With the rolls turning so that the polishing action is downward on each roll, the work is lowered and raised between them automatically any number of times preset on a dial counter. This action is controlled by a hydraulic cylinder mounted above the roll drives. To prevent continuous polishing marks, the workholder oscillates during each pass.

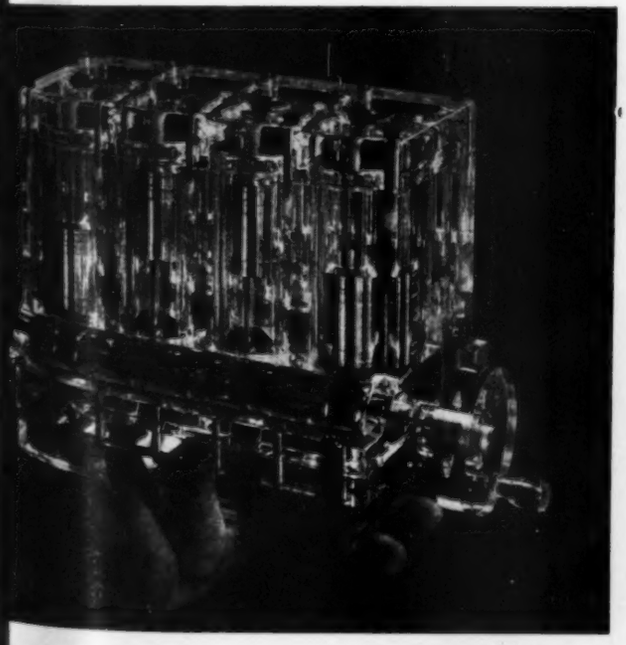
Because each metal reacts differently to the polishing action, the surface speed of the rolls, pressure and cycle time are adjustable, to fit requirements for finishing. Reeves variable-speed drives provide any speed desired between 2500 and 10,000 feet per minute on 16-inch rolls. Screw ad-

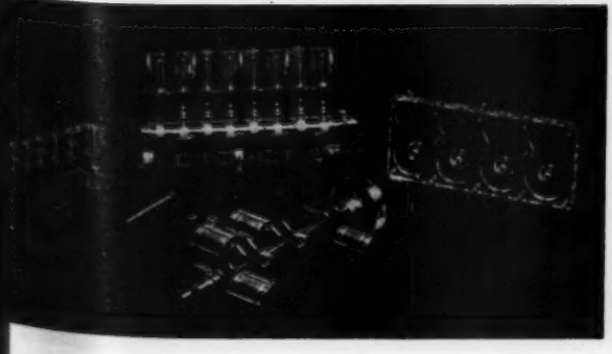
justments position the rolls relative to the work to obtain the required pressure and speed of the work through them is governed by metering the flow of oil from the discharge side of the hydraulic cylinder. Length of stroke is controlled by adjustable strikes operating pilot valves.

Each roll is driven independently so that the surface speed of each may be synchronized after wear causes a variation in diameters. To aid the operator in synchronizing the rolls, ammeters are connected into the drive motor circuits and mounted in the machine frame near the speed ajustment. When the loads indicated on the meters are equal, the surface speeds of the polishing buffs are also equal.



Visual study models are useful for demonstrating design features to prospective users as well as for analyzing motions or characteristics that could not otherwise be studied. An interesting example is the four-cylinder gasoline engine model shown below, illustrating the close tolerances which can be held and the clear visibility attainable with acrylic plastics. Made by Philip A. Derham and Associates, the model is about 8 inches long, 6 inches deep and 4½ inches wide. Block, cylinder head, crankcase, flywheel and motor mounts are machined from solid Plexiglas. The timing gear cover is heat formed of the same plastic.

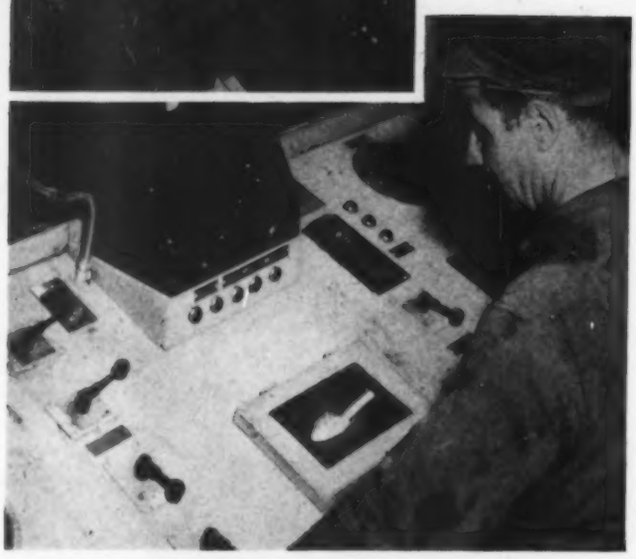




Cylinders are bored to a tolerance of −0.0, +0.001-inch at room temperature with the final finish attained by buffing and polishing. Bore is 1.218 and stroke is 1.125, giving a piston displacement of 5.24 cubic inches and an AMA rating of 2.2 hp. Pistons, wristpins, connecting rods and valves are aluminum. Aluminum rings are designed to give a minimum scraping action. Crankshaft, cam shaft and main bearings are brass. Final polishing of cylinder walls and other surfaces was done with white chalk.

Television may be an invaluable aid to a machine operator who is required to control the co-ordination of processes which otherwise could not be watched simultaneously or which, for health or hazard reasons, are safer to control remotely. An example of the latter, employing a television camera installed over the mold in a continuous casting process at Babcock





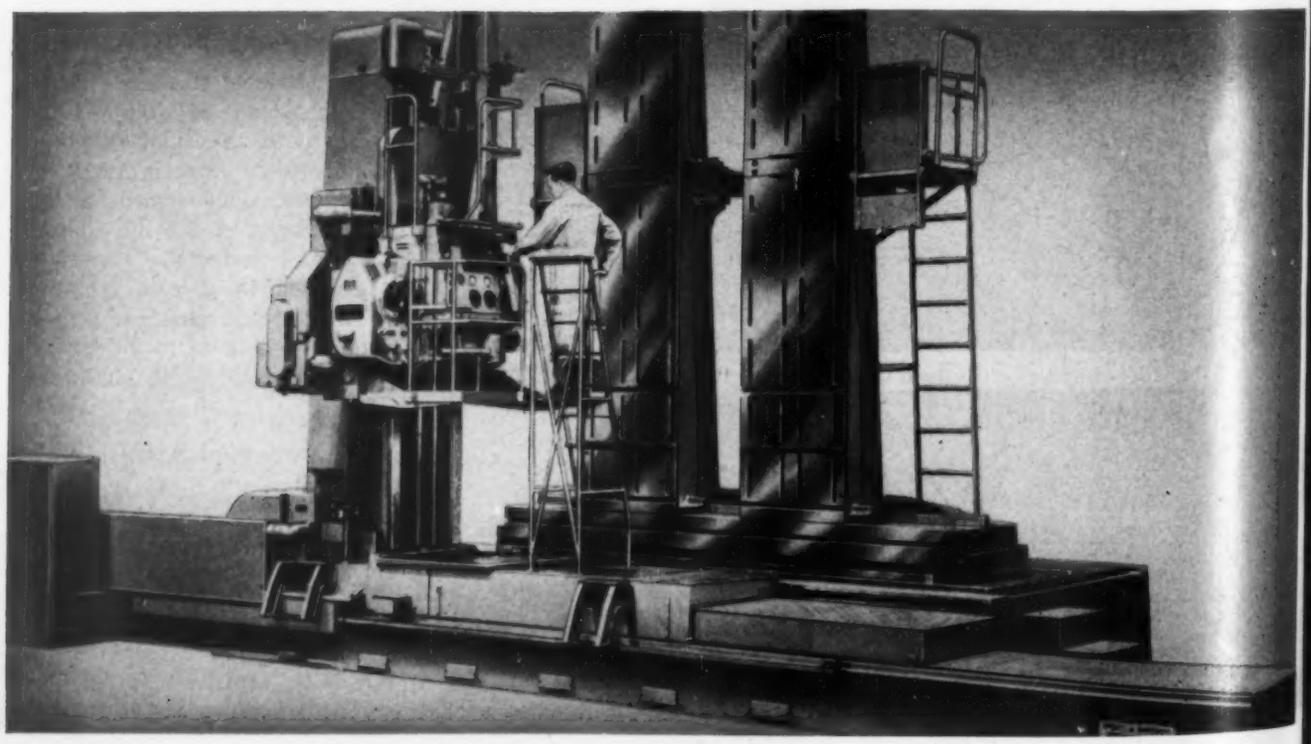
& Wilcox Tube Co., is illustrated at left. A television viewing screen at the control station fifty feet away enables the operator to maintain the proper height of the molten metal in the mold, assuring the casting of dense and sound billets. Built by Diamond Power Specialty Corp., the camera is connected by coaxial cable to the viewing screen and transmits an instantaneous and continuous picture to the control station.

Ideas

Phenolic bearing surfaces on all sliding parts of the Pratt & Whitney tracer-controlled milling machine, below, have eliminated the troublesome problem of wear, resulting from iron-against-iron bearing surfaces on slides. Scoring and wear on slides have plagued manufacturers, particularly builders of heavy equipment, because of the loss of accuracy resulting from the constant movement of heavy masses.

Laminated phenolic plates, sliced edgewise to give an end-grain surface, are fastened to the slides of the column base, vertical slide, and spindle head. These provide for the horizontal, vertical and transverse motions of the machine. Phenolic pins secure the plates to the castings and the surfaces are planed and precision scraped to their mating slides within the same limits of accuracy used for cast-iron bearings. Lead screws drive these heavy members through cast-phenolic nuts, giving a fit that will not freeze.

Tests over a period of years show that bearing surfaces of phenolic against iron or steel will not cut or score the slides and lead screws. With proper lubrication, bearing life may be prolonged almost indefinitely. Besides the nonscoring and good wearing characteristics of phenolic, its heat insulating quality is important for operation under heavy weight.



APPLYING *Torque Converters* TO CRANES

By R. E. Orton
Orton Crane & Shovel Co.
Chicago, Ill.

Part 1–Drive Requirements

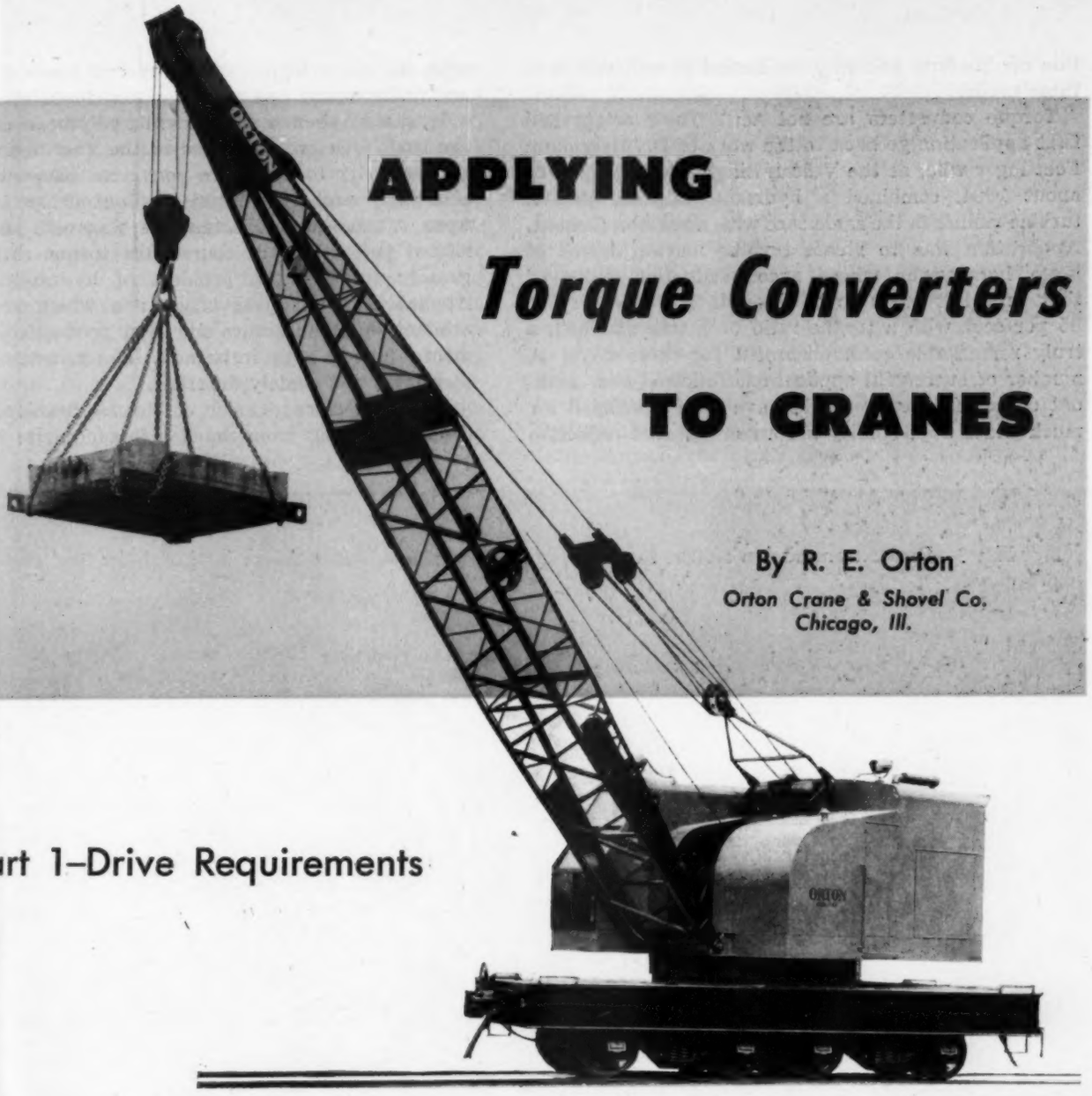
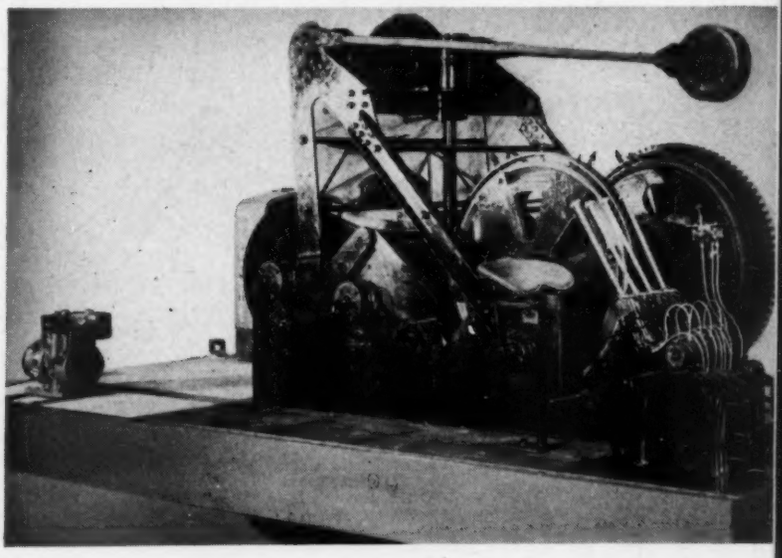


Fig. 1—Above—Twenty-ton locomotive crane powered by a diesel engine. Rotate, boom luffing, double hoist, and travel motions are driven through a torque converter

Fig. 2—Below—Revolving superstructure with cab removed, showing operator's position and main machinery



MANY locomotive crane men still feel, with good reason, that steam is the best operating medium. Steam transmits power substantially without shock— certainly without the shock associated with the conventional geared and friction clutch drive of the internal-combustion engine powered locomotive crane. With steam power, too, the operator can "nurse" a load. By varying his throttle opening he may vary the output, securing a balancing or cushioning effect.

A compromise medium, the fluid torque converter, perhaps does not quite reach the ideal of cushioned handling of steam but approaches close to it without its many problems and nuisances.

This article will discuss some of the problems of operating a locomotive crane and of applying internal-combustion engine power to it, will outline the advantages to be obtained from a fluid torque converter, and will follow with a discussion of a practical field-proved application. Succeeding articles will discuss converter design, the particular converter chosen for

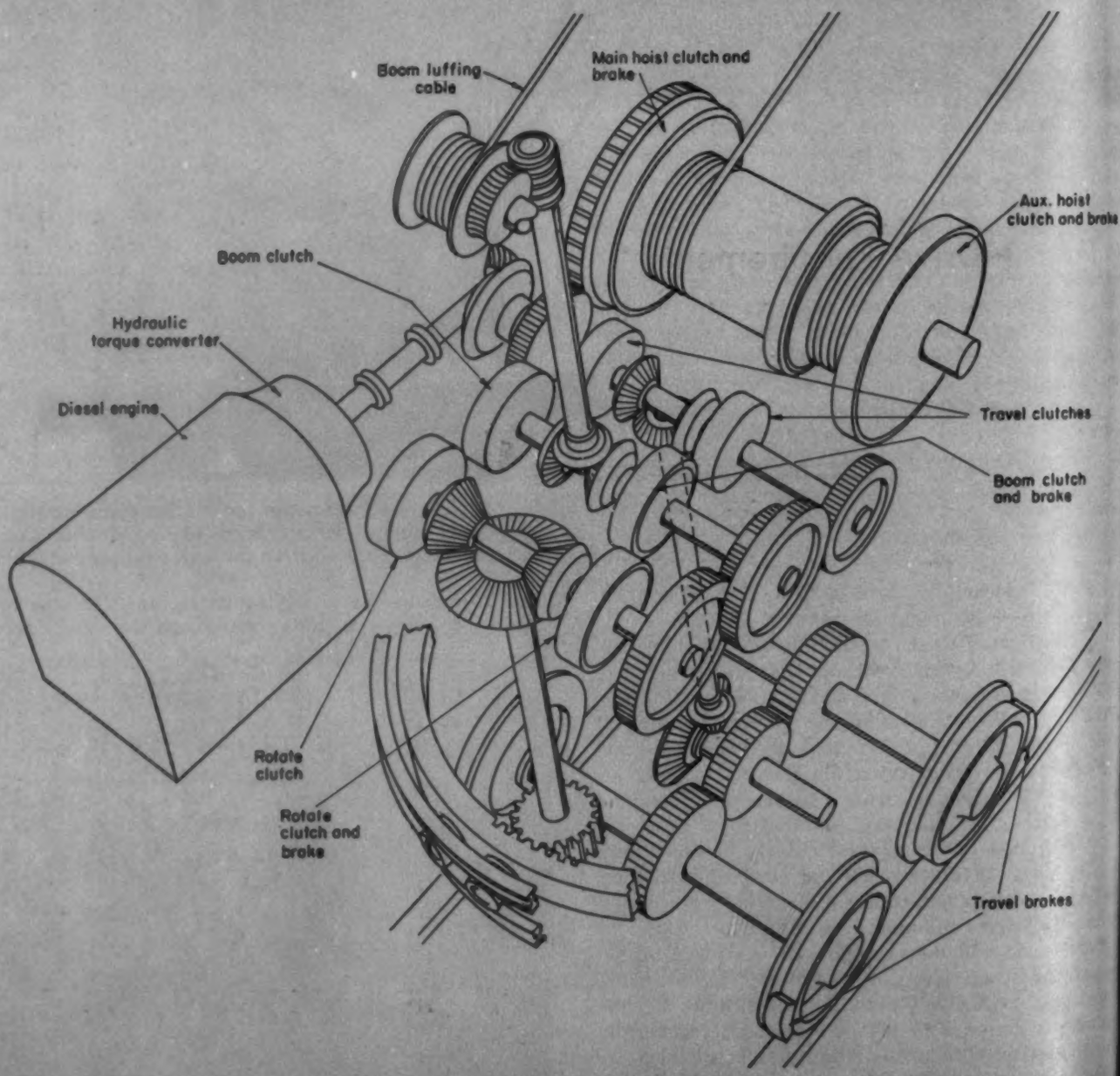
this application, and why its design is well suited to these needs.

Torque converters are not new. Their origin and first application go back to the work of Dr. Herrmann Foettinger who, at the Vulcan Shipyards in Hamburg about 1904, combined a hydraulic impeller and a turbine runner in the same case with a reactor element. Application was to steam turbine marine drives of large horsepower where speed reduction units of that time left much to be desired. An efficiency of 85 per cent with a torque ratio of 5 was attained, a truly remarkable accomplishment for those days. A number of successful applications followed and, without doubt, the device would have been developed for much wider applicability if Parson's geared reduction with its much higher efficiency and lower first cost and maintenance had not been introduced about 1910.

It should be noted that while all the elements of the basic idea are contained in the Foettinger device, all similarity to a modern converter ceases there. In this early unit both input and output shaft speeds were substantially constant, as was also the transmitted power and, of course, the torque ratio. This greatly simplied the problem of hydraulic design. Application was to very large units, which meant that economy of manufacture and mass production requirements did not have to be met. The general arrangement was also widely different.

In 1912 Dr. Bauer, also of Vulcan, developed a hydraulic coupling from the Foettinger device by omit-

Fig. 3—Power transmission system for the four crane motions—rotate, boom luffing, hoist, and travel



ting the "reactor" and applied it to diesel engine marine drives where it effectively damped the vibrations which were so destructive to reduction gearing. An efficiency of 98 per cent was reported, and many similar installations have been made.

About 1926, hydraulic couplings were applied to busses in England, where their success led to applications in other machinery fields. In Sweden, in 1928, the well-known Lysholm-Smith converter was developed. It has been applied widely in England and in this country for both on-the-highway and off-the-highway transportation equipment and other heavy machinery. A good deal of the delay in further application has been due to the many mechanical problems of design and manufacture. There have been difficulties in securing satisfactory sealing, with loss of fluid and the introduction of air which, with vapor formation, results in serious cavitation and marked loss of efficiency.

Is Difficult To Match Requirements

Design of a converter for varying input and output speeds and torque ratios but with a reasonably satisfactory efficiency, has offered many difficulties. In particular has this been true with speeds near synchronous. Even assuming satisfactory design of blade shapes, it has been a problem to produce blades of the required shape, in quantity and at low enough cost to make wide application practicable. Added to all this has been insufficient knowledge of the best methods of applying a converter to machinery. There has not been full realization of the need for designing the converter for the engine and the engine for the converter, and of properly applying the whole to the machine drive.

Conventional locomotive cranes, *Fig.* 1, consist of a carrier (or carbody) capable of self-propulsion and a full revolving superstructure mounted on the carrier. A boom is hinged to the superstructure and its angle may be varied. This superstructure, *Fig.* 2, carries the operator's position, the power unit and the main machinery. The usual machine is capable of four motions: rotating, boom luffing (changing the boom angle), traveling, and hoisting, *Fig.* 3. Since the first three have both forward and reverse motions and the last has two hoist drums, there are eight friction clutches to be manipulated in addition to the various brakes. This affords a complex control job for the operator and requires considerable maintenance for the friction clutches.

Duty Cycle Is Severe

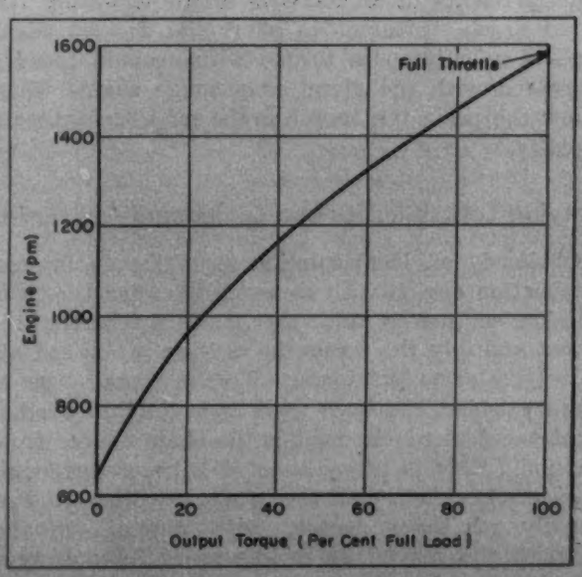
The duty on the boom luffing clutches is light and seldom constitutes a problem. Such is not true of the other three motions. The rotate motion must start against a heavy inertia load under conditions which often call for clutch slipping during a great part of the cycle. Moreover, while a brake is always provided, the almost universal practice is to "plug" to a stop. The hoisting clutches start a relatively low inertia load so their duty from a heat standpoint is not high, but many load-handling requirements call for delicate and accurate manipulation to spot the load. From this viewpoint the requirement is just as severe.

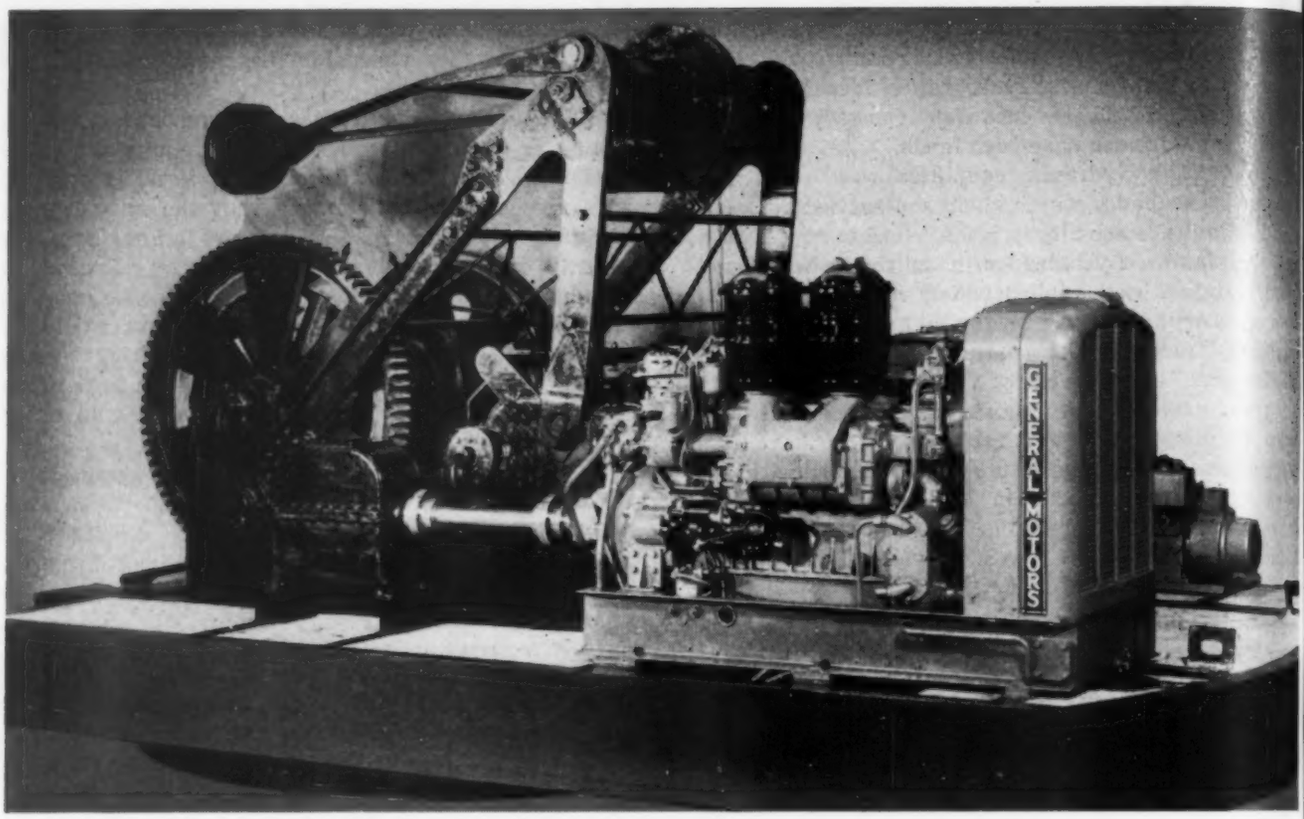
Without doubt the greatest demand is on the propelling or traveling clutches. The requirements are similar to starting a car, truck, or diesel locomotive with mechanical drive, except that the duty is considerably more severe. Locomotive cranes are frequently used as switch engines, being required to maneuver as many as ten loaded cars. Obviously it is not feasible to provide the power that would be available on a unit to be used for switching service only, so that the rate of acceleration is not high. This in itself means long slipping of the clutch to bring the machine to speed.

In addition, the diesel usually must be governed to operate at full speed in order to furnish the desired hoist line speed and to rotate at the desired rate. Even where it may be permitted to "throttle back", the speed may not be reduced too far because of loss of engine torque with risk of "killing" the engine and a further reduction in acceleration. Slipping of the friction clutches, then, must extend over a considerable period, similar to starting an automobile in high gear. It is particularly difficult to handle the machine with delicacy, and there are resultant stresses and severe shocks on the entire traveling mechanism.

It is for all these reasons that steam has been employed as long as it has. With steam the operator may throttle down for starting a heavy load. He may bring the pistons of his engine up against the load, so to speak, and then build up steam pressure and thus build up his push without shock. In the same way he may, to a certain extent, balance his hoist loading requirements, although not to the point of a

Fig. 4—Engine speed under varying output torques with tail-shaft governor control





complete stall. He may even lower heavy loads by allowing the load to pull the engine in reverse and using the compression of the engine to retard the load.

Steam also affords a natural cushioning effect. The low inertia of its engine system tends to reduce the impact stress below the level developed in diesel and gasoline-engine operated machinery. This has been demonstrated in many cases of conversion from steam to internal combustion engines. Unless the change is laid out with care and the minimum size of engine is used, it invariably results in broken shafts and gears. Moreover, and more important, it usually results in an increase in the operating time to do a job. Steam also offers the decided advantage of a build-up in torque with drop in speed as compared with the diesel or gasoline engine where, below the peak, the torque drops off with increasing rapidity.

Varying Torque Ratios and Cushioning Are Desired

Obviously an ideal solution would be an internal-combustion engine with some medium for the transmission of power into the main machinery that would multiply the torque in varying ratios and also afford the same cushioning effect as steam. One accessory which has been used frequently to partially meet the first requirement is the change-speed transmission. This is often inserted between the engine disconnect clutch and the main machinery. It is usually of three speeds, with normal operation through the second or middle speed. By dropping into low speed, a greater starting torque is obtained as well as a lower governed speed for manipulation. By shifting into high speed, high travel rates are obtained. Frequently a reverse is provided for lowering heavy loads.

Use of the change-speed transmission has been a material gain in internal-combustion engine applications, but it has introduced other problems. The duty requirement calls for heavy transmissions and, in many cases, it has been necessary to build them especially for the job. This has meant high initial and maintenance costs. While constant-mesh type, jaw-clutch shifting transmissions are usually used, the rotating parts are of such size as to make shifting while under way difficult. Also, the shock results in over-stressing of gears and shafts.

Gear Transmission Requires Heavy Parts

On some installations the change-speed gearing is put in the travel function only and is mounted in the carbody. This reduces somewhat the shocks and strains on the superstructure machinery. However, it requires a still heavier transmission with still heavier rotating parts to shift. Moreover, the control of the shifting, from the operator's position in the rotating superstructure to the nonrotating carrier and into the gear case, has been difficult. It is already necessary to carry one or two air pipes through the rotating center, for the operation of the carbody brakes, and sometimes additional pipes for sanders and other accessories. Location of the transmission under the carbody also makes it vulnerable to serious damage. Locomotive cranes are used under conditions which lead to derails, and the undercarriage must be built to withstand such derailment with a minimum of damage. It is hard to build a gear

Fig. 5—Left—Crane superstructure from corner opposite the operator, showing the converter power unit, spiral bevel gear drive and floating shaft flexible couplings



Fig. 6—Right—Twenty-five ton crane, showing the engine through access door. Power unit may be removed through this door for servicing

case in this location which is of sufficient strength to withstand the entire weight of the crane and, in particular, to withstand the entire weight of the crane when dropped through a distance. Moreover, clearance dimensions must be met, and the case cuts into this space to the extent that it is difficult to lay out gears of sufficient size.

Numerous Types of Transmissions Are Utilized

Naturally there have been many attempts at solving the locomotive crane problem. One that has received considerable attention and extensive application is electric transmission of the travel power. In one arrangement the diesel drives an electric generator and, through the armature shaft of the generator, a silent chain drive sprocket supported by an outboard bearing. The chain drive transmits power into the main machinery for operation of the other three functions. The electric power generated is transmitted to two series-wound direct-current motors mounted one on each truck of the carrier, with drive by enclosed gearing into one axle of each truck. Functionally, this electric transmission of the propelling power has been successful.

The electrical layout itself is, as a whole, relatively simple. Ward-Leonard control is commonly used, that is, the generator field current is varied to control the output voltage to the motors. This gives a smooth transmission of power with a minimum of electrical contacts and controls. The travel clutches are eliminated and the necessity for carrying mechanical power through the rotating center of the machine is also eliminated.

This electrical system is not, however, entirely free from mechanical problems. The geared reduction from the motors to the axles necessitates at least a double-reduction drive. The gear cases are subject to derailment damage because the location of the equipment on the trucks makes adequate reinforcement difficult. Two cases and motors are required, one on each truck. It is also necessary to transmit the electrical power from the revolving superstructure to the carrier, requiring a collector ring arrangement which introduces maintenance problems.

The initial cost of electrical propulsion is higher than that of a geared drive. At first thought this seems surprising, the propelling clutches and related parts all being eliminated. However, almost as much mechanical equipment is required as in the conventional arrangement. The electrical equipment will vary from 50 per cent to as much as 100 per cent more in cost than the conventional geared drive. Nevertheless, it has offered enough of a functional gain to be used for severe-duty requirements, such as are present in steel mills, for example.

Diesel-electric propulsion offers no help to the other three motions. They are still geared and employ friction clutches. Since, next to propulsion, duty requirements are most severe on the rotate clutches, cranes have been designed using an electric drive for rotate motions also. In the usual arrangement this has meant the incorporation of a second electric generator, as well as a rotate motor, with generator field control. The reason for the second generator is because field control could not be used if a common generator were employed. Instead it would be necessary to employ resistance control with its contactors, resistors, wiring, and other equipment.

A compromise solution that avoids the high cost of the electrical system employs a fluid coupling between the engine and machinery. In the usual arrangement the coupling is mounted on the engine flywheel, the power passing through a disk type disconnect clutch and a three-speed transmission into the main machinery, just as described with the conventional geared machine. The disconnect clutch is necessary to permit shifting of the gears. Normal drive is through second speed as before, giving a low speed for extra traction, when required, and a high speed for travel.

This design is an improvement in that it filters considerable vibration and torque peaks of the engine drive from the machinery. It is a mistake, how-

ever, to think of a fluid coupling as being a "soft" power transmission device, particularly as used here. It is unquestionably an improvement over the friction clutch and it certainly does not entail the wear and maintenance problem of a friction clutch. However, a fluid coupling operating at anywhere near full speed will not permit much drop in speed of the driven member so that its engagement with the load still leaves a good deal to be desired.

Coupling Has Torque Limitations

This is an important point that is well worth thought. As outlined before, except when car switching or traveling alone, the engine must generally be operated at full speed. Now, a fluid coupling puts out exactly the torque put into it. But this does not mean that it cannot transmit more than engine peak torques. Momentary loads may be applied to the output shaft so as to borrow energy from the inertia system lying on the engine side of the coupling just as in a geared drive. At full speed the usual coupling will slip about 3 per cent under full load. With double torque load this slip will be nearly 6 per cent —not much of a cushion.

Momentary overloads are developed in shifting the transmission gears, in harsh application of the propelling and rotate clutches which leads to sudden reversal of gearing, or in the hoist when the slack comes out of the line. In such cases momentary peaks occur, and the hydraulic coupling does not give much relief to these peaks. Actually, the fluid flywheel adds appreciably to the inertia of the system from which the transients can borrow.

Converter Reduces Impact Loading

As torque converters were further developed for industrial use it became natural to experiment with them in place of the fluid coupling and with the change speed gears completely eliminated. These converters offered all the advantage of the fluid coupling in eliminating engine cyclical vibration. It was also discovered that, even with the engine operating at full-load speed, there was an inherent softness in load shifts that was not present in the fluid coupling and which served greatly to reduce impact peak loadings. At full load and 1:1 torque ratio, a typical converter application might show a slip of 10 per cent. At double torque load this slip may be 50 per cent or more compared with a coupling change from 3 to 6 per cent. Shock to gears and shafting is almost completely eliminated, as are impact and vibration loads from the engine; and the duty on operating clutches is greatly reduced.

Moreover, the torque ratio change furnished a "change speed gear" with infinite steps and one which acted automatically without attention from the operator. On switching jobs the load could be applied so as to stall the output shaft, bringing its "shoulder against the load" just as was done with the steam engine, giving a smooth acceleration to high speed.

However, early applications showed that the greatest virtue of the converter was also its greatest defect or so it appeared. It was difficult to secure uniformity in line speeds. This proved troublesome for load handling, particularly for bucket work. Control became difficult, and operators found the action confusing. In particular it was disconcerting in the early forms of converters where the 1:1 slip may actually be as high as 40 per cent. Efficiency, too, at this point was as low as 60 per cent and dropped off from this value as the output speed increased.

The first step in overcoming this trouble was the development of the automatic coupling-converter where the stator was allowed to free-wheel as synchronous speed was approached, so that full load 1:1 ratio slip was brought up to 10 per cent or less and efficiency to over 90 per cent. This arrangement and action will be covered in more detail in a later article.

Governor Controls Output Shaft

The second step was the introduction of tail-shaft governor control, where the output speed was held constant and the engine speed allowed to float—a case of the "tail wagging the dog." This, coupled with a throttle control arranged to over-ride the governor to give the operator torque output control for car switching and speed control for high-speed travel, swept away the last problems attendant upon the introduction of torque converters on locomotive cranes. Details of how this is accomplished and its presentation will also be left for a later article.

Some idea of the results from the use of the converter with tail-shaft governor control may be gained from an examination of the curve in *Fig.* 4. The tail shaft is governed to 600 rpm. The curve shows engine speed versus output torque in per cent of full-load torque. Under idle conditions the engine runs at near shaft speed. As the load is applied the engine speed increases to develop the power needed, the converter automatically furnishing the torque ratio required to handle the applied loading. The engine runs no faster than needed.

Equipment arrangement is shown in *Fig.* 5, a view of the crane superstructure from the corner diagonally opposite the operator. The converter is mounted on the engine flywheel with its housing bolted to the flywheel housing to furnish a complete unit type power take-off. The engine sub-base carries the converter hydraulic sump, and the heat exchanger for disposing of the converter heat to the engine cooling water may be seen. This sub-base carries a complete power unit consisting of the engine with all its accessories, radiator, fan and drive, air cleaner, tachometer, controls, etc. An engine-mounted air compressor supplies air for the clutch controls.

Drive from the tail shaft is through gear type floating shaft flexible couplings into the spiral bevel gear drive mounted in the oil case that may be seen at left center, *Fig.* 5, and thus into the main machinery. By simply sliding the coupling sleeves back, the entire power unit may be removed for servicing through the access door seen in *Fig.* 6.

The next article in this series will present briefly an analysis of the fluid action in couplings and converters to illustrate this particular application. The third article will show how the combined throttle and tail-shaft governor control was developed.

Straight-Line Motion

. . . produced by simple mechanisms

By Paul Grodzinski
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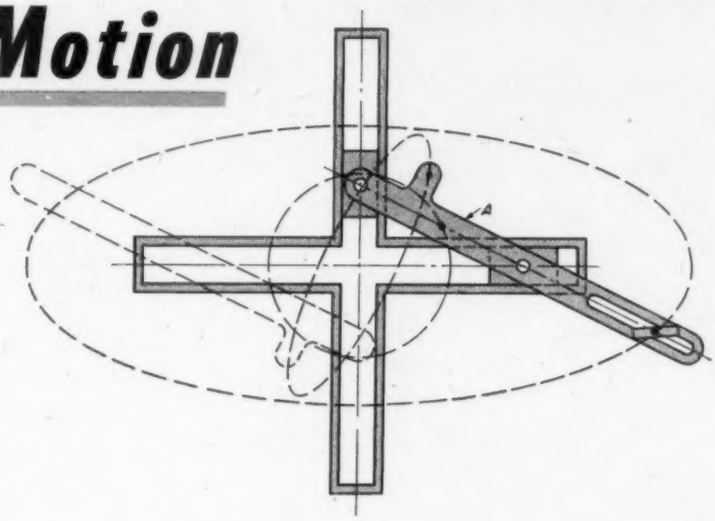


Fig. 1—Elliptical trammel, a basic mechanism from which various linkages that give straight-line motion can be derived

LINKAGES that give straight-line motion have long been a classic pursuit of kinematicians. An excellent survey of this subject was given recently by H. G. Conway[1] in MACHINE DESIGN. That review included the four-bar linkages of Watt, Roberts and Tchebicheff and the six to ten-bar systems of Peaucellier, Hart, Sylvester, and Kempe. Though intriguing in their theoretical aspects, the latter mechanisms are quite complicated and, because of the many joints or pivots, not as feasible in realization as the four-bar linkages, which have all found practical applications. To this group of simple linkages can be added other straight-line mechanisms that are easily applied. These systems, all reported in earlier literature, are described in this article.

For obtaining straight-line motion with simple mechanisms, the following possibilities exist: (1) mechanisms derived from the elliptical trammel or the circles of Cardano; (2) mechanisms derived from that producing the conchoid; and (3) four-bar linkages and derived mechanisms.

[1] References are tabulated at end of article.

ELLIPTICAL TRAMMEL DERIVATIONS: The elliptical trammel, *Fig.* 1, consists in its usual form of two guideways fixed in the form of a cross and a bar which slides with two points in the guides. Then, every point of this member describes an ellipse with the exception of the two guided points which lie on straight lines and the center which describes a circle.[2] One of the guideways may be omitted and the member *A* guided by bar *B* which, on one end, is fixed to the middle of the member and, on the other, is fixed in the center of the guideways. Thus, an isosceles slider-crank mechanism, *Fig.* 2*a*, has been formed. End *p* of bar *A* describes an exact straight line. From this linkage an approximate straight-line mechanism, *Fig.* 2*b*, may be derived by fixing link *B'* at any arbitrary point *q'* and making the length of *B'* equal to the radius of curvature *r* of the ellipse at point *q*. Thus, in a limited range a good approximation is ob-

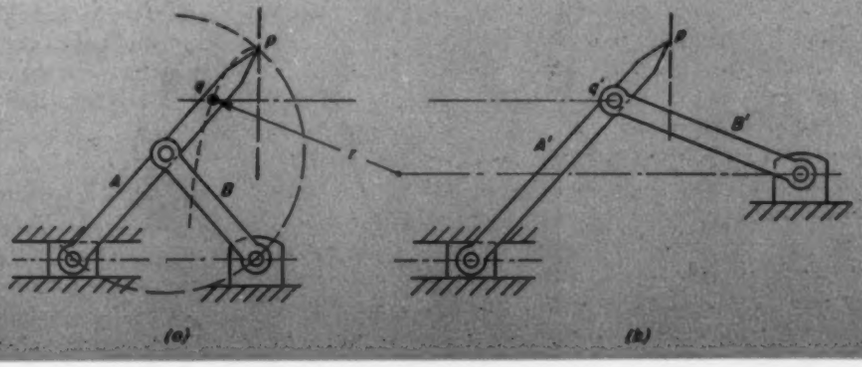


Fig. 2—Mechanism derived from the elliptical trammel for exact straight-line motion is shown at *a*. This linkage is shown converted to an approximate system (first form) at *b*

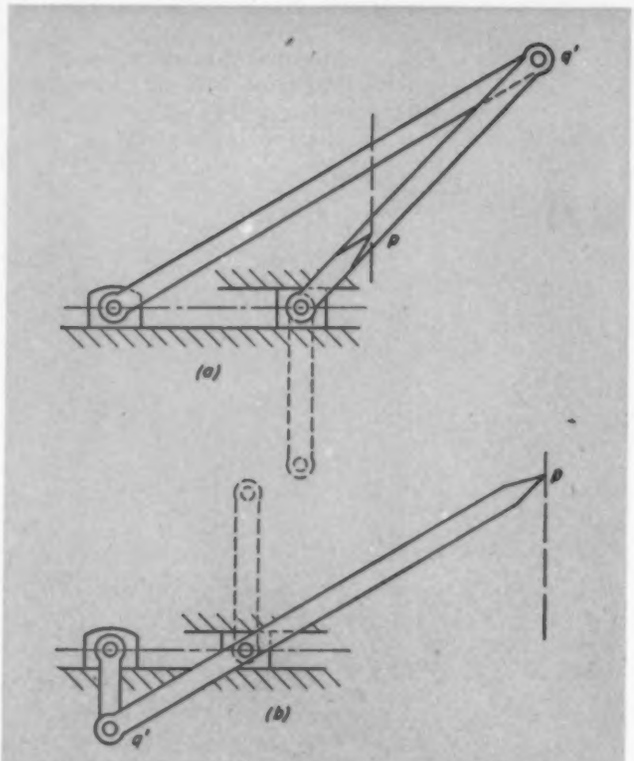


Fig. 3—Above—Second form, *a*, and third form, *b*, of approximate elliptical movement

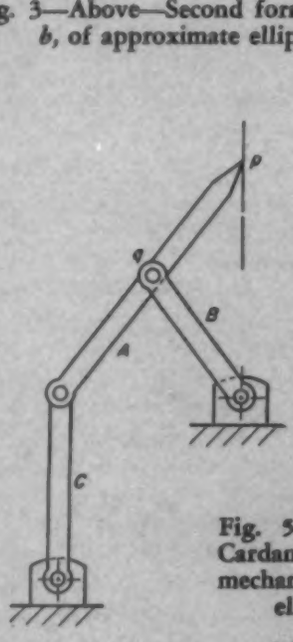
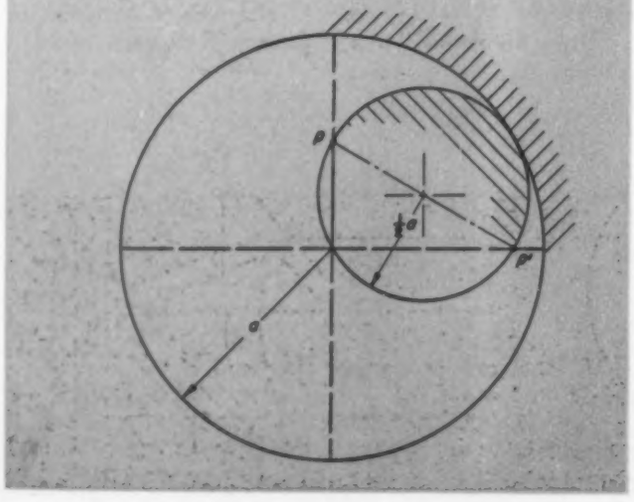


Fig. 4 — Left — Evans straight-line mechanism

Fig. 5—Below—Circles of Cardano, a hypocycloid mechanism paralleling the elliptical trammel



tained. Point *q'*, instead of being between the slide and point *p*, may be placed beyond point *p*, *Fig.* 3*a* or beyond the slide, *Fig.* 3*b*. Mechanisms of *Figs.* 3*a* and 3*b* are known as approximate elliptic linkages of the second and third form, whereas *Fig.* 2*b* is a mechanism of the first form.

These mechanisms, in contrast to those shown in the original article,[1] have a sliding pair, the last vestige of the elliptical trammel. Evans has replaced this sliding pair by another link *C*, *Fig.* 4. This mechanism is frequently used on engine indicators, and may be used in the second and third forms as indicated in dotted lines in *Figs.* 3*a* and 3*b*. Actually, these mechanisms are four-bar linkages which will also be mentioned later.

Special Hypocycloid Applicable

The elliptical trammel, *Fig.* 1, and its adaptation in *Fig.* 2, may be considered from a more general viewpoint, *Fig.* 5. Here, the centrodes of the movement have been drawn. For the elliptical trammel the fixed centrode becomes a circle with radius *a*. The movable centrode is another circle with radius $\frac{1}{2}a$. As it rolls along the inside of the large fixed circle, it always passes through the center of the large circle and the two points *p* and *p'* move along the axes of the large circle just as two points slide along the guides of the original mechanism. The remarkable property of this mechanism of interest in this connection, however, is that *any* point on the periphery of the small circle describes, during rolling, a straight line passing through the center of the large circle. The basic principle of this system is called the "circles of Cardano." The best known mechanism of this kind is an external pinion rolling within an internal gear of twice the pinion diameter —a special type of epicyclic gear. This hypocycloid mechanism seems to have been first described by the English engineer, James White, about 1800. It has been used extensively in printing machines up to the present day because it gives a long stroke.

CONCHOID DERIVATIONS: For mechanisms of this type use is made of a mechanism for the generation of the conchoid of Nicomedes, a curve of the fourth degree with the equation: $(x^2+y^2)\ (x^2-b^2) = a^2x^2$. The mechanism is the angle-slide chain, *Fig.* 6*a*, a derivation of the four-bar linkage with two sliding and two rotating pairs. Every point on member *A* of the mechanism, *Fig.* 6*a*, describes a conchoid which near the horizontal axis has a curved form followed by an inflection point. Therefore, slide *S* may be replaced by a member *B* resulting in the mechanism shown in *Fig.* 6*b*. Again, the junction of *A* and *B* may be varied in position as explained with the approximate ellipse movement.

FOUR-BAR LINKAGES: The most important linkages of this type have already been discussed in the original article.[1] However, *Fig.* 7 shows another form of Watt's mechanism in which the straight-line lies outside the points guided on arcs. This approximate straight-line mechanism might also be considered a variation of Evans' linkage shown in *Fig.* 4.

Geometrical considerations on linkages by Kempe,

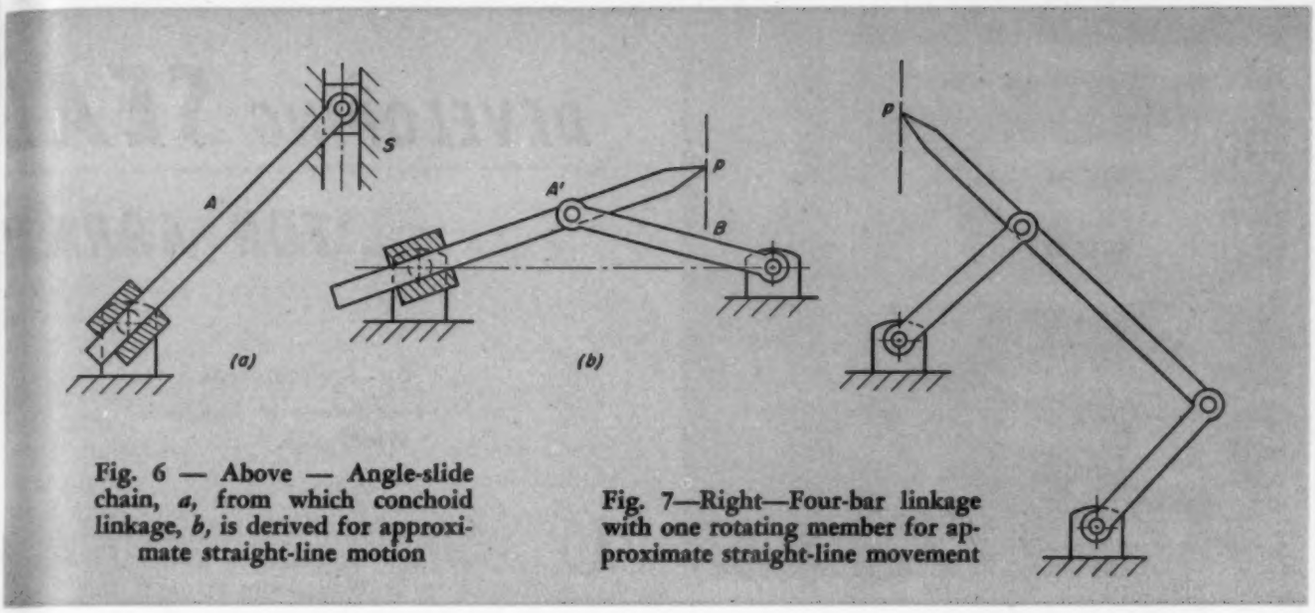


Fig. 6 — Above — Angle-slide chain, *a*, from which conchoid linkage, *b*, is derived for approximate straight-line motion

Fig. 7—Right—Four-bar linkage with one rotating member for approximate straight-line movement

Hart and Sylvester have led the German geometrician, L. Burmester, to further investigations of the nature of the curves described by the connecting link of four-bar linkages. He developed an ingenious geometrical system, published in 1888[3], which permitted determination of such curves containing straight sections. This theory was further developed by R. Mueller in different papers between 1891 and 1902. Since the scope of straight-line mechanisms in engineering is admittedly restricted, his investigations and results, ably redemonstrated by R. Beyer[4] in 1931, remained an interesting piece of geometrical thought. But with the advent of efforts to synthesize mechanisms, in particular to construct four-bar mechanisms for given conditions, the work of Burmester was again used by M. Gruebler and H. Alt who designed linkages with members that for some periods come to a standstill. The development of these mechanisms is not yet concluded, but they opened many applications to linkages where formerly only periodic mechanisms such as cams, ratchet and indexing gears could be applied. Therefore, the intensive occupation with straight-line linkages proved not in vain, but in some respects served as the foundation for new and interesting practical developments.

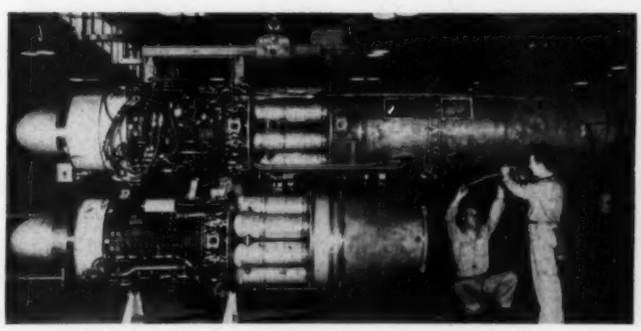
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Reheat Burner Gives Planes Added Punch

ADDED thrust for Air Force planes is available through the use of the elongated General Electric jet engine which burns additional fuel in a "reheat" burner in the tail. By burning fuel in the tailpipe, in a method called "exhaust reheat," the thrust or driving force of the engine is increased. The augmented engine was developed by the company's aircraft gas turbine divisions at Lynn, Mass., and is being test flown in the North American F-95A, a higher-flying and extensively modified version of the F-86 jet fighter which holds the official world's speed record of 670.981 miles per hour. Another experimental reheat power plant has also been test flown in the Republic XF-91.

The experimental reheat engine has a special nozzle at the end of the tailpipe, a clamshell-like device through which exhaust gases are discharged. The movable lips, automatically controlled, change the area through which the hot gases must pass to obtain optimum performance from the engine under varying flight and power conditions. The illustration shows a comparison of the new engine with the old J-47 production model jet engine.



DEVELOPING SEAL FOR ABRASI

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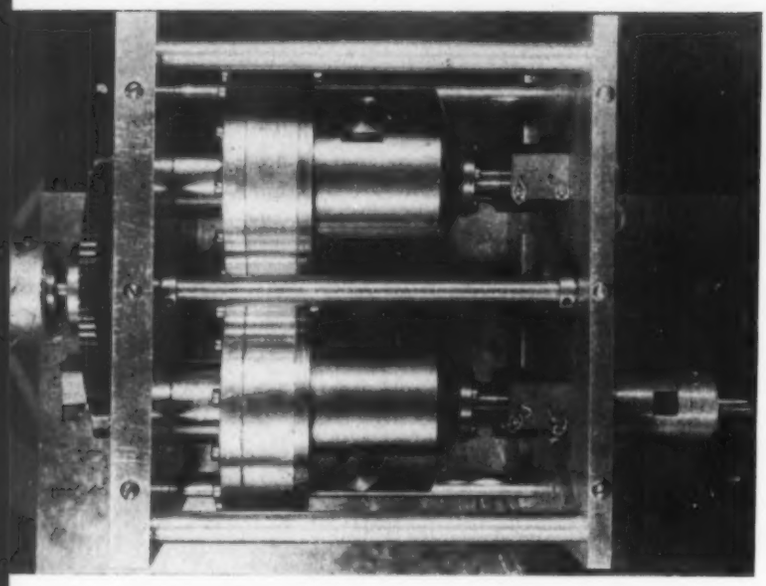
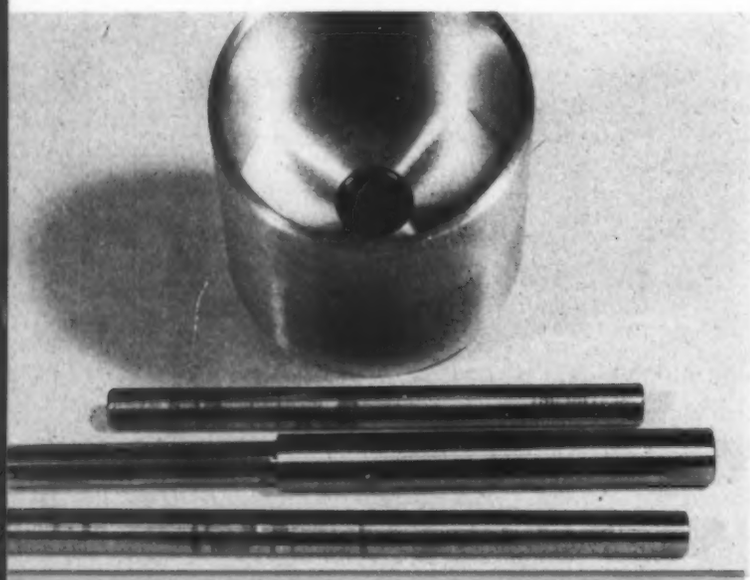


Fig. 1—Above—Magnetic-fluid clutch servo utilizing iron separator and pump between shaft seals

Fig. 2—Below—Test equipment for checking commercial shaft seals



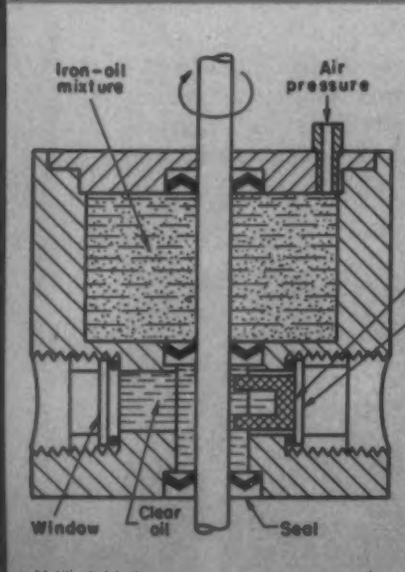
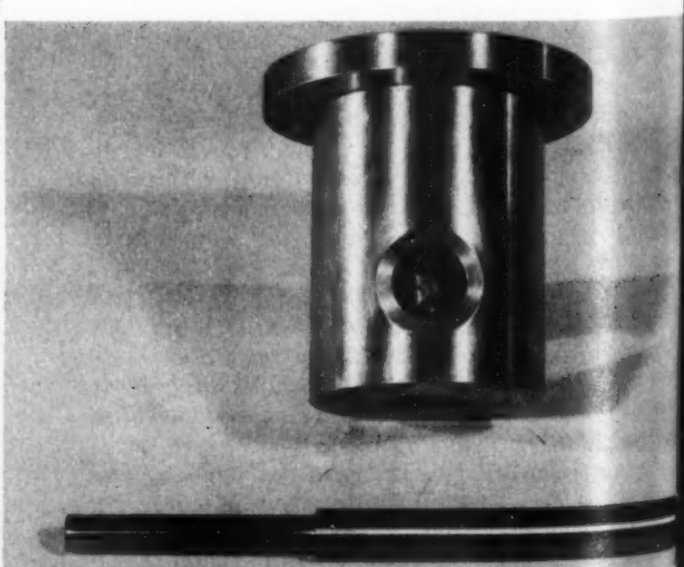


Fig. 3—Left—Device for testing sealing efficiency of commercial seals backed by clear fluid

Fig. 4 — Right — Test equipment shown in *Fig.* 3 for checking effect of clear fluid backing on commercial seals. Magnet attracts particles that may pass the seal

UNIQUE features of the magnetic-fluid clutch, originally developed by the National Bureau of Standards in 1948, have made it the subject of extensive investigation in both Government and industrial laboratories. As a result, valuable information has been obtained on a number of design problems—such as heat dissipation, settling of the magnetic powder, and hermetic sealing—which are important in industrial applications. This article will deal primarily with shaft seals for this clutch, *Fig.* 1, but because the sealing problem is related to other features of the clutch these will be reviewed first.

The clutch is based on the principle that the frictional forces between solid surfaces and certain types of fluid media can be controlled by the application of magnetic fields. In its simplest form, the device consists of two parallel magnetic plates separated by a powder composed of finely divided magnetic particles. When a magnetic field is established between the two plates, the magnetic particles bind the plates against movement parallel to their surfaces. Though simple in principle, the development of an industrially acceptable clutch is quite another matter. Many problems, too numerous to mention here, arose after the original successful experiments. Some of the problems are similar to or identical with those present in



SIQUID MIXTURES

other clutches but others are peculiar to the magnetic fluid clutch.

Like all others, this clutch must dissipate energy when slipping. The only time a clutch does not do this is when it is either completely disengaged, resulting in a zero torque condition, or when completely locked, resulting in zero relative speed between members. At all values between these two extremes, it will be transmitting some torque at some value of slip. Since torque in a simple clutch—distinguished from torque converters—is the same on both shafts and since the speed of the two shafts is different under conditions of slip, the power output is not equal to the power input. Expressed in per cent, the difference in power is the same as the difference in the two speeds. This kind of operation requires that the clutch dissipate the difference as heat, a requirement which is true of all clutches irrespective of type.

Development of the magnetic-fluid clutch has drawn attention to this problem because it can be built in very small sizes and may be slipped without harm if the effects of heat can be overcome. To dissipate heat requires operation at elevated temperatures and this gives rise to several difficulties. One is the deterioration of the materials from which the clutch is made; examples are breakdown of insulation, oxidation of the metal parts, evaporation or polymerization of the lubricant, dimensional changes of the parts, expansion of the air and liquid contained within the clutch, breakdown of gaskets, etc. An obvious way to overcome some of these difficulties is to make the clutch large in relation to its power capabilities so as to reduce the operating temperature. Cooling fins and other expedients well known to the art can also be employed. Another approach is to use materials that will tolerate the highest possible temperatures. This can be carried only to a certain point, and does not help to minimize breathing and oxidation of the lubricant and iron powder. However, these solutions are not always satisfactory, particularly for military applications where small size and weight for a given horsepower rating are extremely desirable.

Early in the work it became apparent that hermetic sealing of the clutch mechanism would be desirable. Such sealing is employed in the fluid couplings used in automobiles. The difficulty, however, was that no known shaft seals were suitable for this application. It was found that the iron powder would soon abrade and destroy any of the seals tested. Certain expedients could, of course, be used to keep the powder out of the seal. These include mounting the clutch with the shaft vertical so as to make use

Fig. 5 — Right — Fixture for testing permanent magnet filtering of fluid mixture

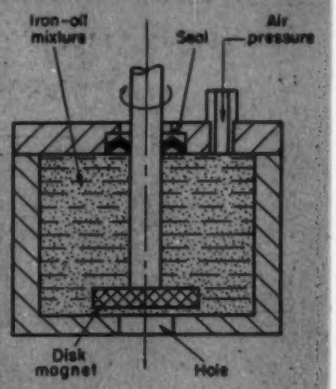


Fig. 6—Below—Magnetic separator test equipment using a permanent magnet with radial poles

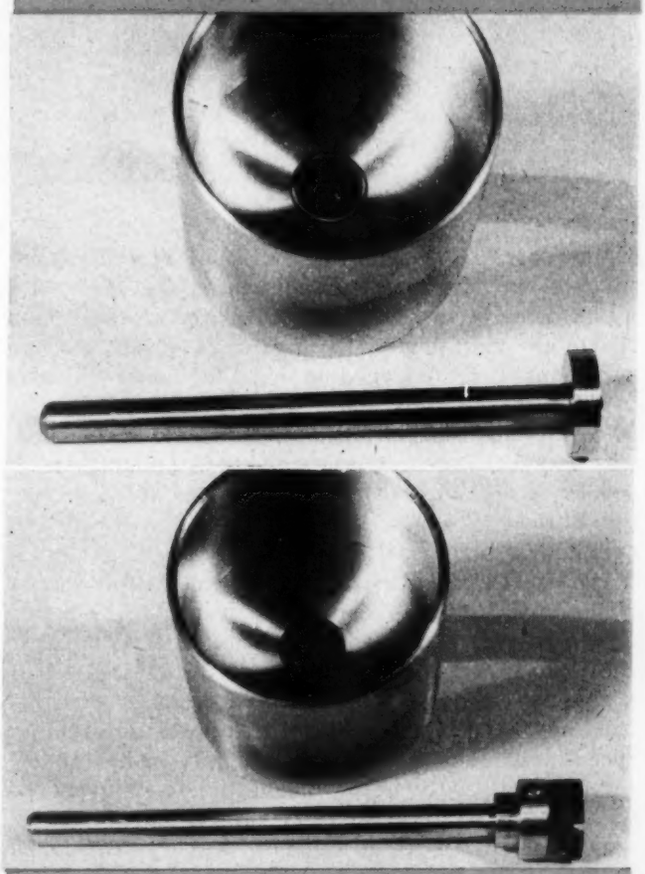
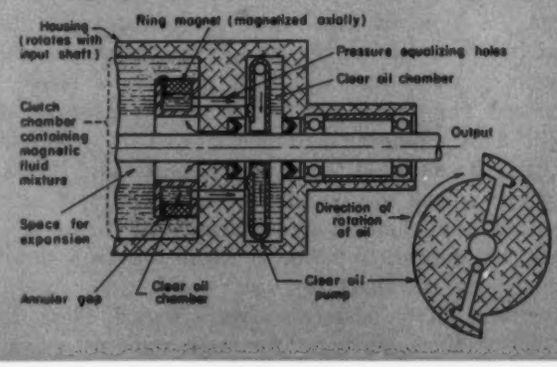


Fig. 7—Above—Magnetic separator equipment using permanent magnet with consecutive circumferential poles

Fig. 8—Below—Successful seal which pumps clear oil in chamber between two shaft seal members, preventing abrasive particles from entering



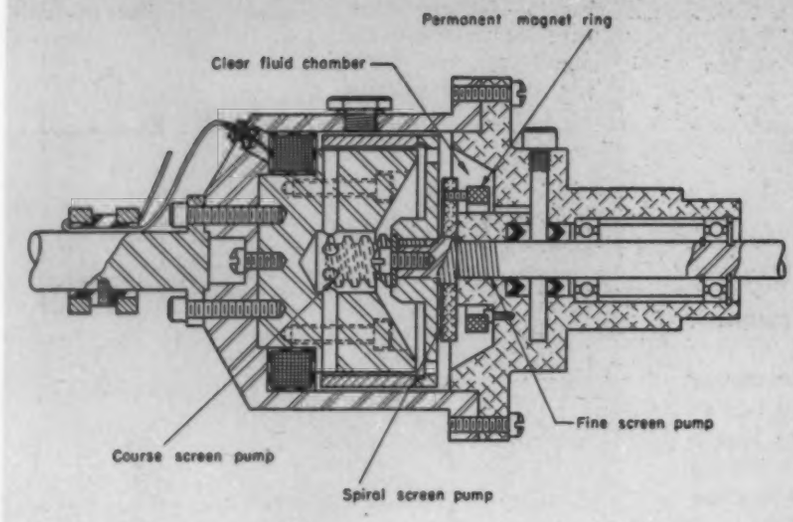


Fig. 9—Left—Section through clutch showing early model of seal which led to development of final seal

Fig. 10—Right—Magnetic-fluid servo clutch using seal shown in sectional view in *Fig.* 9

of the force of gravity, and the use of centrifugal slingers, labyrinths, spiral threads on the shaft, etc. Again, none of these is satisfactory for all conditions of clutch operation. Manufacturers of shaft seals and many firms engaged in handling abrasive mixtures, such as paints and ceramics, were queried but no shaft seal suitable for the magnetic-fluid clutch was found. Research was therefore undertaken to develop a special seal. This work was sponsored by the Bureau of Ships, Department of the Navy, and culminated in the seal to be discussed.

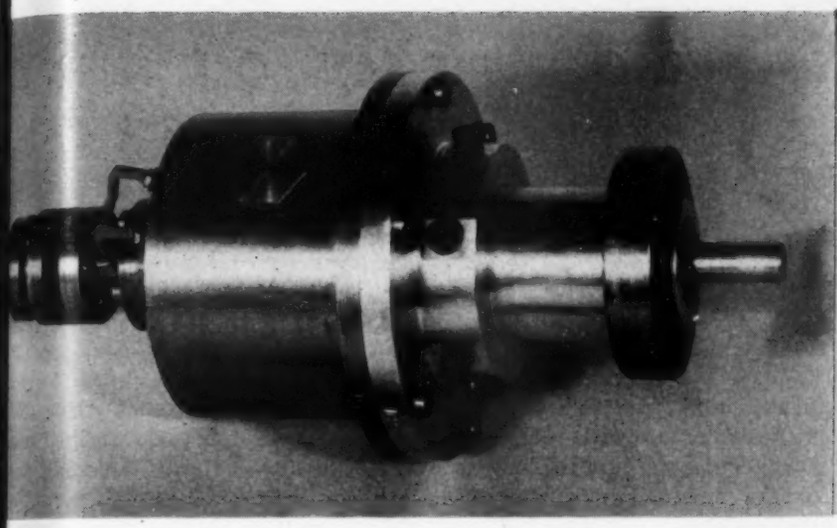
Equipment used in this development followed a standard pattern. A drill press was used to rotate shafts passing through the bottoms of brass fixtures, *Fig.* 2. These fixtures were provided with various types of seals and filled with mixtures of carbonyl iron and oil. The shafts were driven at different speeds and leakage through the seals could be observed readily. Some of the fixtures were provided with covers so arranged that air pressure could be applied to the top of the iron-oil mixture to simulate pressures developed due to temperature rise in actual clutches. Various types of seals were tested such as standard rubber packing, O-rings, felt seals, and special Teflon seals but none proved successful. A double-shaft seal with clear oil between the two seals, *Figs.* 3 and 4, worked for a short time until the quantity of the oil between the seals diminished due to leakage. Then this combination behaved like all the others. A type of shaft seal yet to be tested is a spiral brush or rubber seal, made to contact the shaft in such a way that the iron powder is swept or squeegeed along the shaft toward the inside of the clutch. This sweeping action, followed by a standard seal, may be suitable for some applications. It would not serve where the clutch has to be shipped or operated in any position and where centrifugal action cannot be depended upon to keep the iron powder mixture from the shaft.

Magnetic shaft seals also were tested, *Figs.* 5, 6 and 7. Various types of magnets were attached to the ends of shafts and located slightly above the opening in the bottom of the fixture. It was found that, when the shafts were revolving, oil and iron would always get through the magnetic seal. Both permanent and electromagnets were tried, the latter being supplied with both direct and alternating currents. One of the interesting phenomena, however, was that when the shaft was not rotating, only clear oil passed through the magnetic gap and all the iron was retained in the fixture, as in the well-known magnetic separator. This rediscovery led to the final development of a successful shaft seal.

It was fairly obvious that if clear oil could be continuously pumped toward the inside of a clutch along the shaft surrounded by an ordinary rubber seal, iron particles would be continuously washed back into the clutch and would thus be prevented from getting under the rubber and harming the seal. The problem was to get the oil out of the clutch again so that this process would be maintained indefinitely. The magnetic separator provided the answer. The seal as finally developed is shown schematically in *Fig.* 8. The clutch shown is provided with an auxiliary chamber containing clear oil, and the whole system is sealed by a second seal operating only in the clear oil. Seals for the latter are commercially available.

It was feared that a permanent magnet ring in the clutch might attract all the iron powder, thus making the clutch inoperative. For this reason the magnet was so shaped and located that centrifugal force would tend to throw the iron away from the magnet and into the working gaps. Also, a rather weak magnet was employed in the first model, *Figs.* 9 and 10. This did not prove successful but showed promise. A second model was built having a strongly magnetized ring magnet with a very short working gap so that its external field is small.

A test model of this magnetic filter was built using a loud-speaker magnet, *Fig.* 11. Provisions were made to apply hydraulic pressure to the filter, *Fig.* 12. It was found that this magnetic separator worked ex-



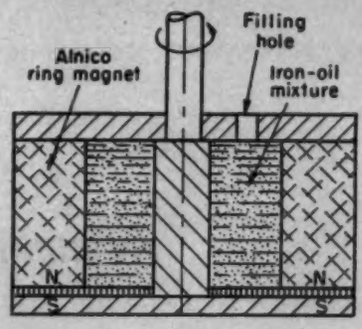


Fig. 11—Axial-flux magnetic separator. Gradient is toward the gap all around the shaft

cellently, permitting only clear oil to pass through the gap.

Because of the concentration of the field in the gap, little iron was actually attracted from the outside and the magnetic filter did not clog. Centrifugal action and the action of the magnets of the clutch itself keep most of the iron powder where it is needed. The clutch using this structure is shown in *Figs.* 13 and 1. It was tested continuously under conditions of slip from 0 to 200 per cent, i.e., with the shafts driven in opposite directions, for more than 200 hours without any iron passing either seal and with the oil in the second chamber remaining perfectly clear.

When this clutch was first tested it was completely filled with oil and, as expected, the rise in temperature expanded the oil, creating internal pressure and causing leakage through some of the gaskets. This was rectified immediately by partial filling of the clutch. Centrifugal force threw the oil and the mixture outwardly so the shaft ran dry and the flushing action in the inner seal ceased to function. A pump was then added to the clutch, and so positioned in the clear oil chamber that the oil was at all times carried from the rim of the auxiliary chamber toward the inner shaft seal and forced along the shaft into the clutch housing, *Figs.* 8 and 13. The pump is of the simple impeller type as can be seen in the illustrations. Other types of pumps may, of course, be used. The outside seal in the model is a duplicate of the inner seal, that is, a rubber ring seal around the shaft, since such seals were readily available. For long-life, high-pressure applications, proper seals of the axial type would be more desirable.

This composite seal is undoubtedly somewhat complicated and expensive, but if made in quantity as a package unit, its cost should become comparable to that of the other components in the clutch. Such a package could consist of a housing containing both the inner and outer seal, the magnetic filter, and the oil circulating pump. By careful design, the overall size of the assembled unit could be kept within reasonable limits.

Grateful acknowledgment is given to Israel Rotkin, H. Duncan Saunderson and James Palmer, all of the Bureau staff, who have done most of the work on the magnetic-fluid clutch seal.

Fig. 12—Below—Test fixture for magnetic-iron separator using axial field

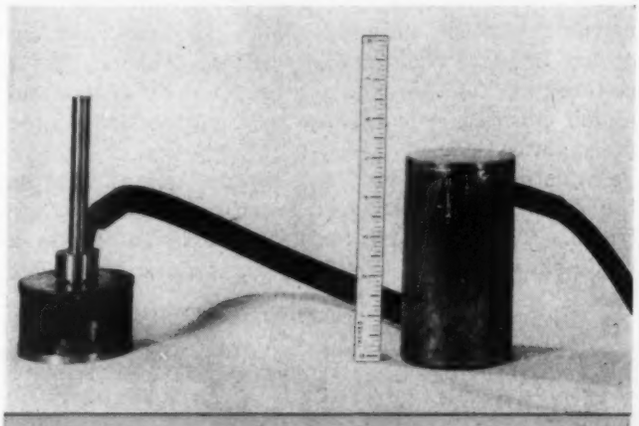
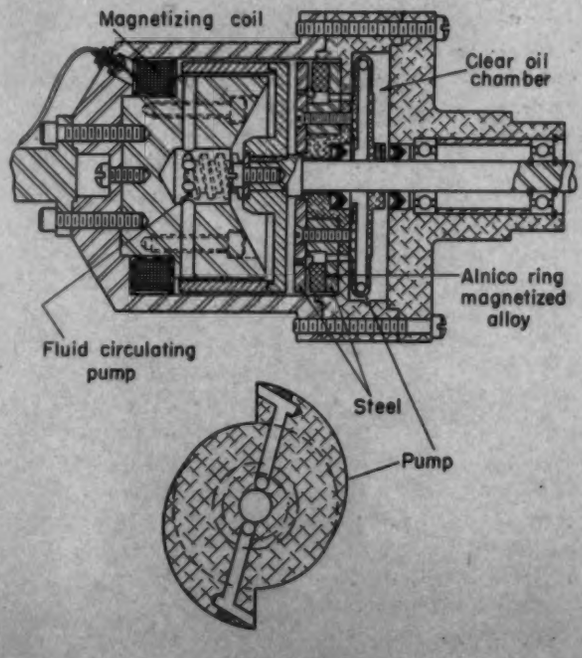


Fig. 13—Below—Magnetic-fluid clutch shown in *Fig.* 1. After 200-hour test oil in chamber remained clear

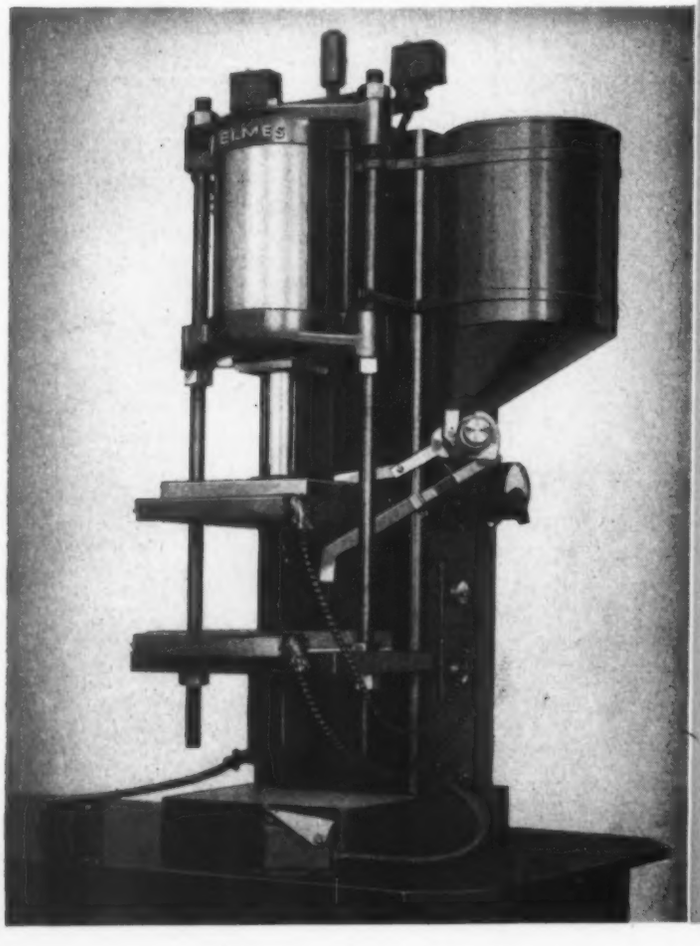


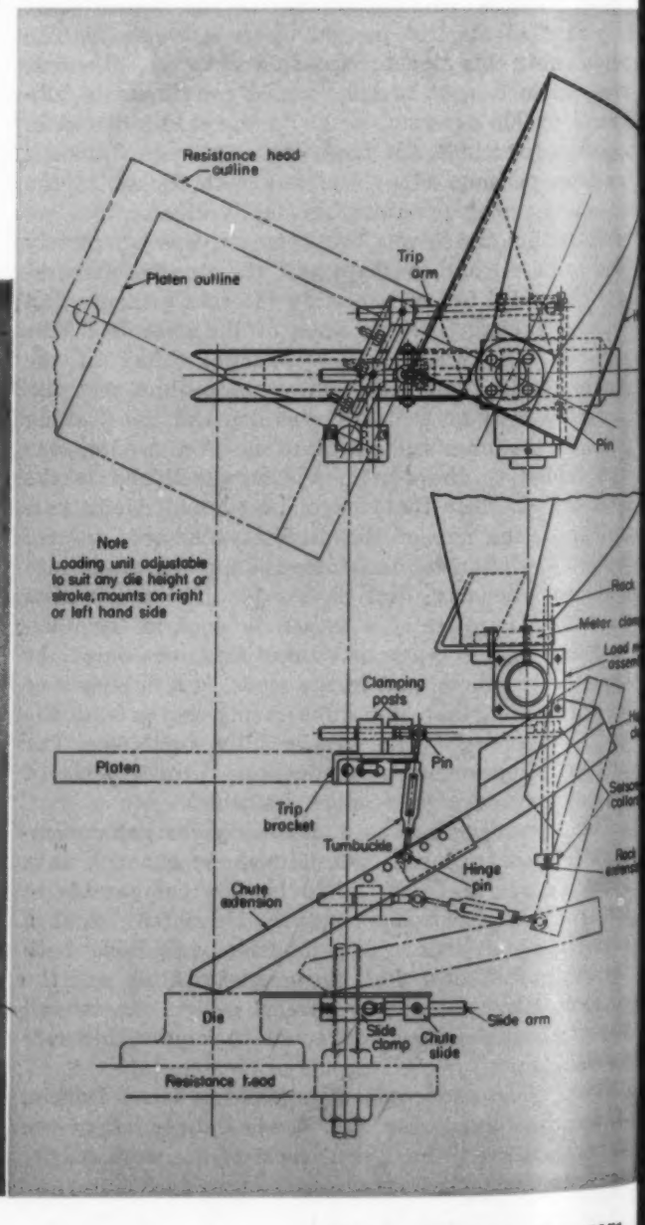
Automatic Loader Speeds Plastic Press

MOLDING press, operating automatically and continuously, increases production rates of plastic moldings. Developed by Elmes Engineering Division of American Steel Foundries for the new low-pressure, fast-setting, mineral-filled alkyd resins, the press, illustrated below, has a hopper feed device which loads material into the die cavity. As the press platen moves down, a turnbuckle linkage folds the two-piece chute which pivots at its upper end and moves out of the die space to the position shown by dotted lines in the drawing, below. The charge is metered by a device which is actuated by a rack and pinion engaged by a fork or trip arm carried on the press platen.

Adjustments are provided for amount of charge, the point at which charging occurs, and the chute travel. The nose end of the chute is guided on a chute slide, clamped to one of the press columns. The loading mechanism is reversible for mounting on either the right or left side of the press frame, and up to four loading units may be used for multiple cavity dies.

Two 1350-watt, 10-inch square aluminum hot plates, carried on the platen and lower resistance head, have cast-in heating elements. Bottom plates are drilled to permit passage of the knockout rod, which is automatically sequenced on the return movement of the





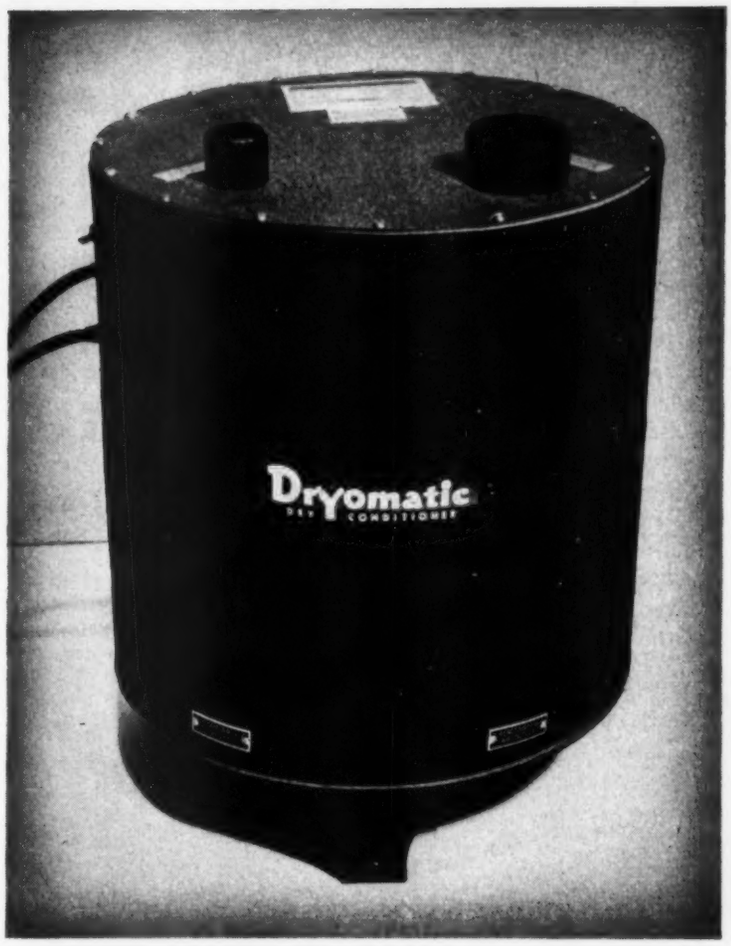
platen. The molded part is first removed from the die by the air-operated knock-out rod and is then ejected from the die area by an air blast bypassed from the knock-out cylinder.

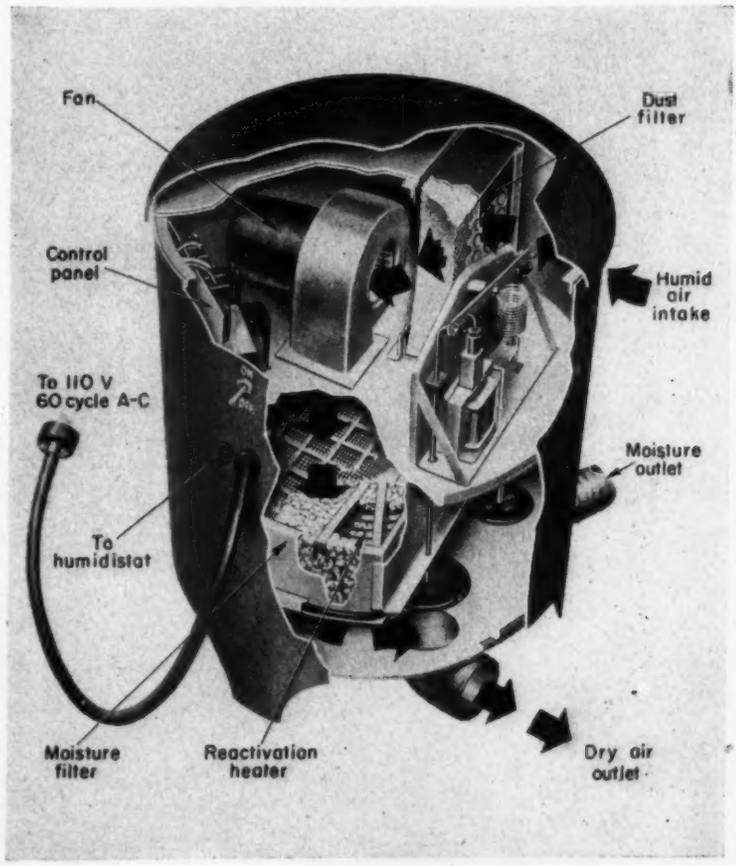
Controls are simple. A pneumatic timer is the only relay type unit employed in the electric circuit, the remainder of the functions being controlled by limit switches and conventional manually operated switches. Molding pressure is obtained from air or water-operated cylinders, with an adjustable timed pressure dwell of from 0.3-second to 3 minutes. In addition to the automatic press operation, single-cycle controls are provided for insert molding.

Humidistat Controls Dehumidifier

AUTOMATIC humidity control unit shown, above right, will hold the relative humidity as low as 15 per cent in a 10,000-cu ft sealed storage area. This Dryomatic unit removes moisture by adsorption and is controlled by a humidistat set for the desired relative humidity. Air is drawn from the room through a dust filter by a fan which forces the humid air through a moisture filter which adsorbs the moisture from the air, cutaway view right. The dried air is then discharged back into the room. After the chemicals in the moisture filter become saturated, they are automatically dried by a timed reactivation cycle. In this process, the fan continues to run and a timer-controlled solenoid valve mechanism closes the dry air outlet and opens the moisture outlet. An electric heater then heats the saturated chemicals, evaporating the adsorbed moisture which is exhausted outside the room. After this chemical drying cycle has continued for about 40 minutes, the valve mechanism automatically shifts back to the room-drying cycle.

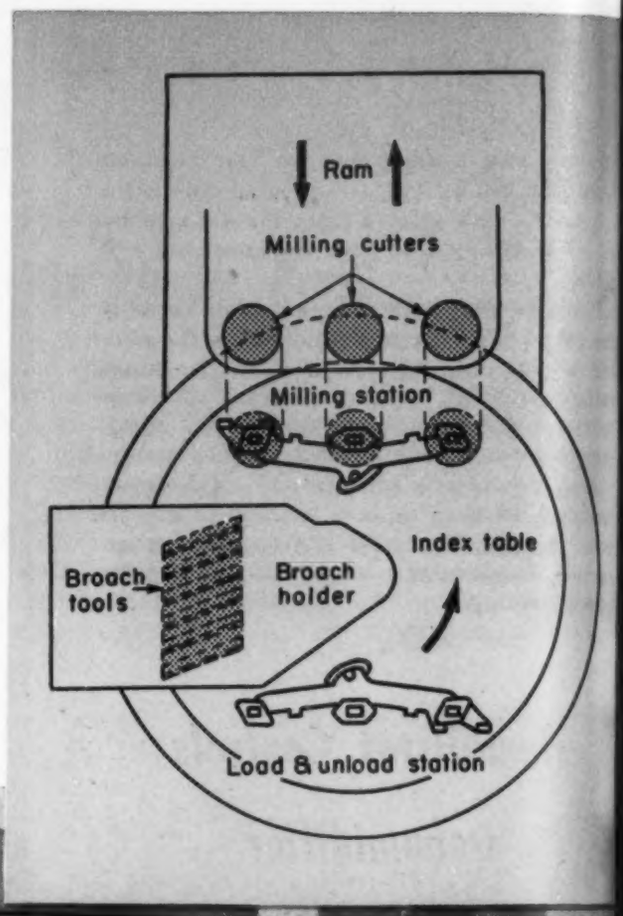
The dehumidifier will run continuously during the initial dry-down period until the excess moisture has been removed. Then, the unit turns off and on to maintain the humidity set on the humidistat regulator, in the manner of a thermostat. This model removes one gallon of water per day at 70 F and 50 per cent relative humidity.

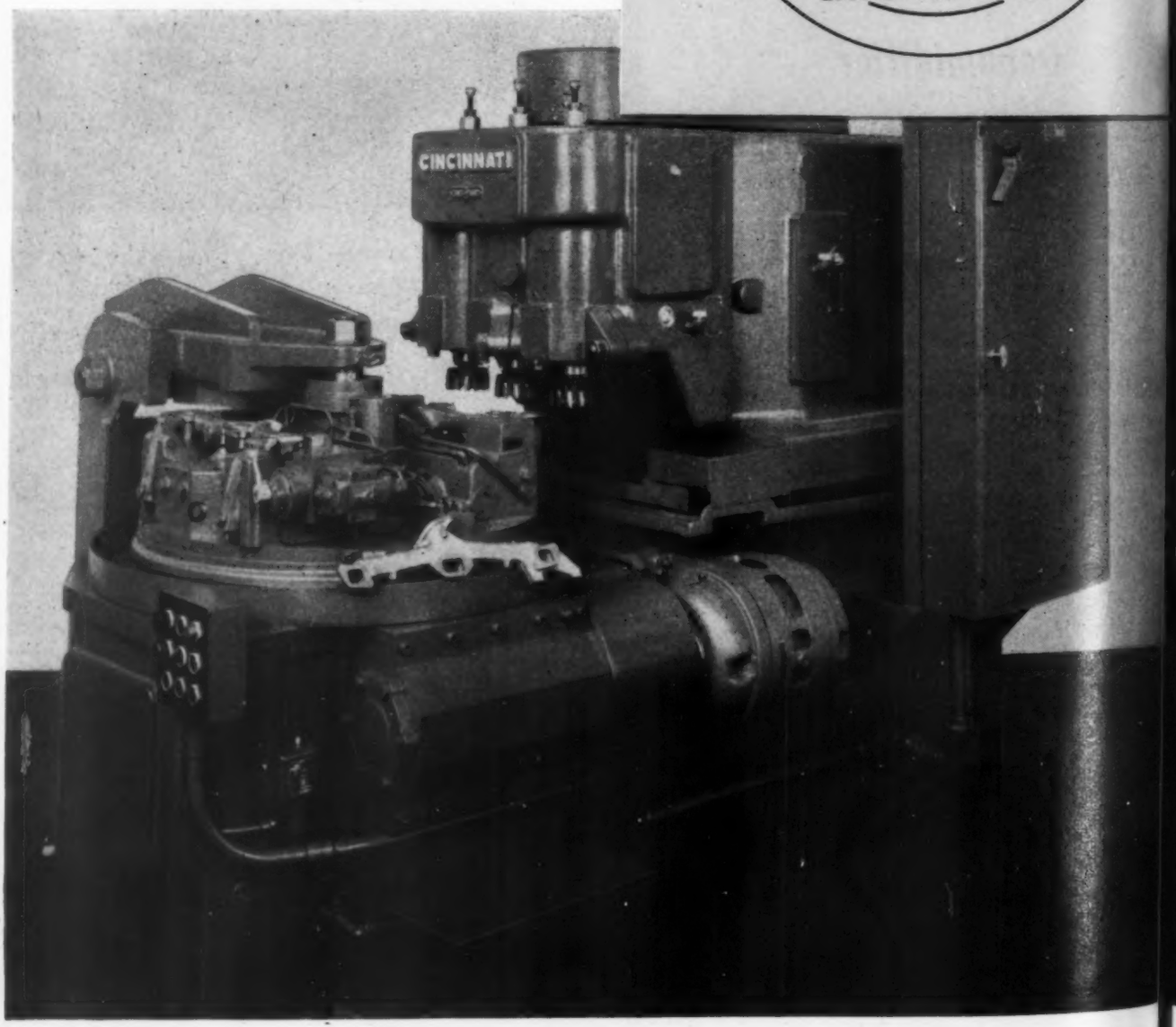




Mill-Broach Cuts Machining Time

MACHINING time on automotive exhaust manifold is reduced considerably by combining two operations in a single special-purpose machine. The Cincinnati Milling and Grinding Machines Inc. rotary mill-broach, below, has cut total cycle time—rough milling and finish broaching of three port pads—to 0.3-minute per manifold. Parts are loaded on a 36-inch diameter rotary table, right, and indexed to the milling position. A hydraulically-operated ram advances the three-spindle 210-rpm milling head for the milling operation. Then the spindle carrier is raised, the ram retracts and the table indexes, carrying the manifold under the stationary broach to the unloading position. Approximately ¼-inch of stock is removed by the milling operation and about 0.007-inch by the broach.





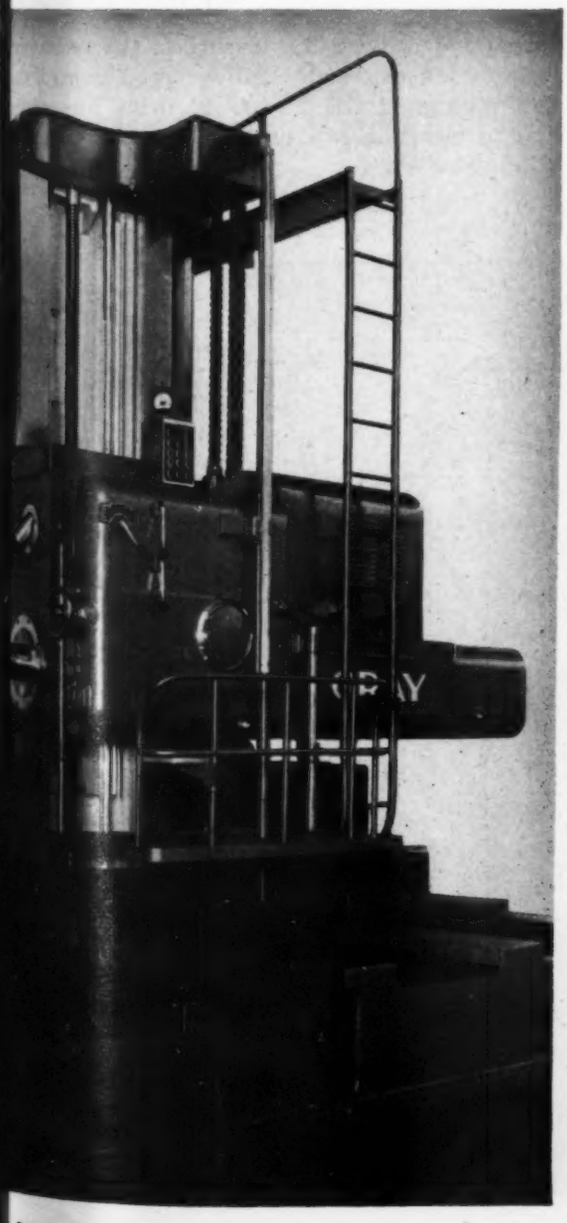
CONTEMPORARY DESIGN

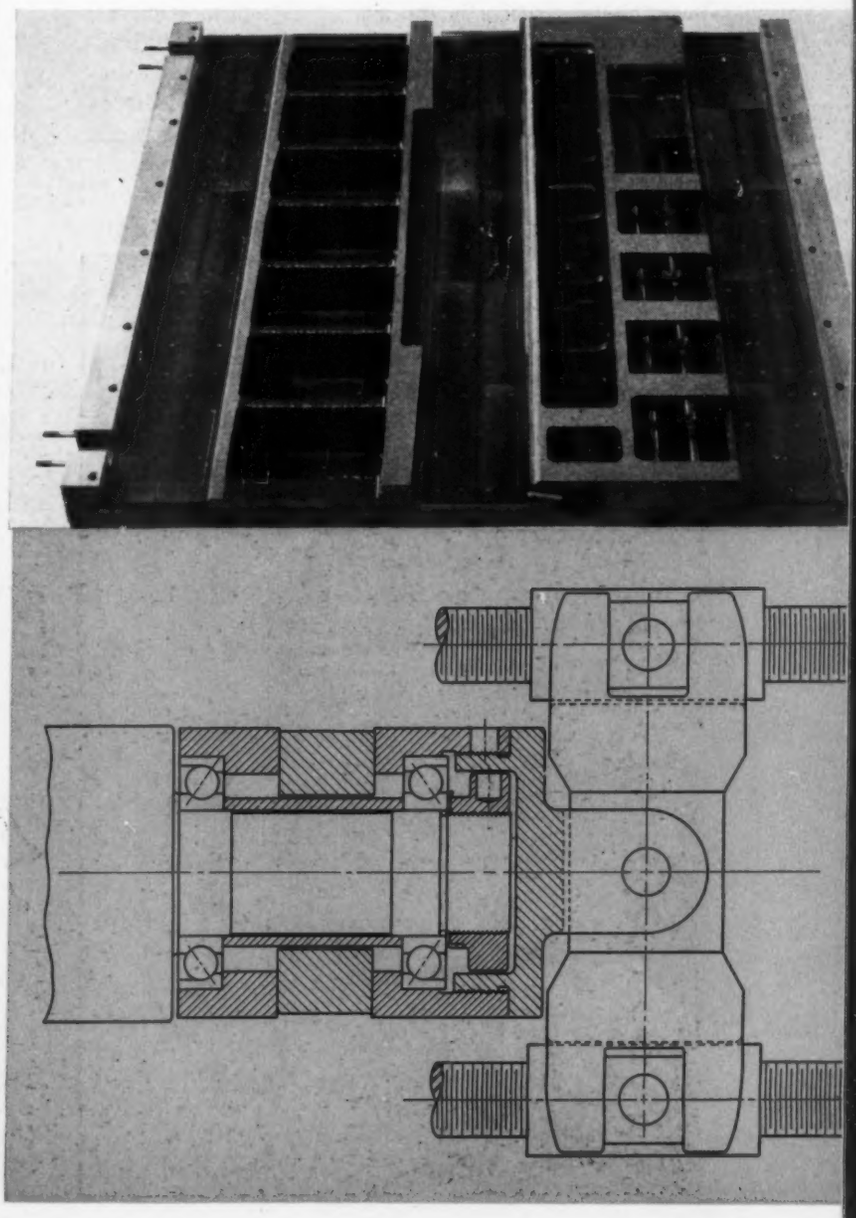
Boring Machine Features Long Feed

SIZE of the G. A. Gray Co. 8-inch floor type horizontal boring, drilling and milling machine, below, does not impair its precision. Power positioning of the head and column, for instance, is accurate to 0.00025-inch. Spindle has four speed ranges, up to 600 rpm, with six speeds within each range obtained through hydraulic planetary gear shifts.

One of the unusual features of this machine is the feed bar device, drawing below, using two feed screws. Each of these feed screws carries a sleeve or nut, rather than a conventional single feed screw and sleeve-and-pinion arrangement. This design eliminates a loose sliding member and permits continuous uninterrupted feeds up to 84 inches, approximately doubling previously available feeds on machines of this type. Also, feeding pressure is concentric with the bar axis and, therefore, there is no tendency to wear the bar bushings bell-mouthed. In addition, positioning and boring of long holes is facilitated by the elimination of "taking another bite" on the bar.

The boring machine saddle in the photograph below shows the underside of the saddle which is provided with nonmetallic ways. These laminated plastic bearing surfaces minimize the possibility of scoring guide





CONTEMPORARY DESIGN

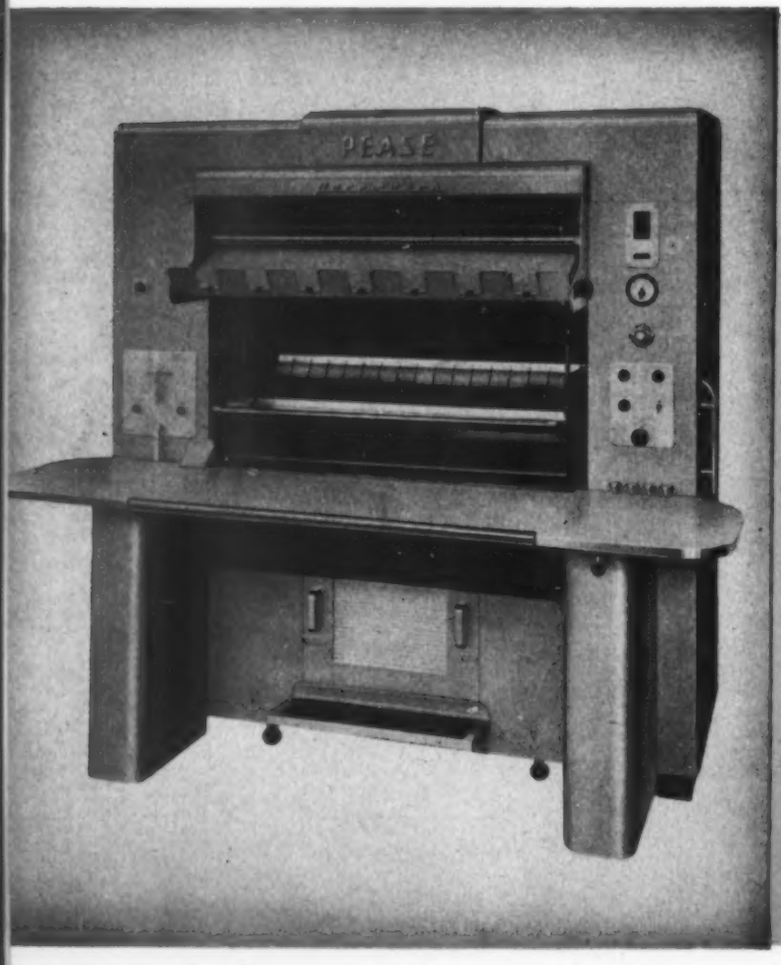
surfaces and permit hitherto prohibitive unit bearing loads which are sometimes encountered when a machine is not properly leveled. The lubrication system supplies an anticipatory shot of oil to bearing surfaces prior to the start of feed or traverse and during machine operation, a continuous stream of oil is also supplied to these bearing surfaces.

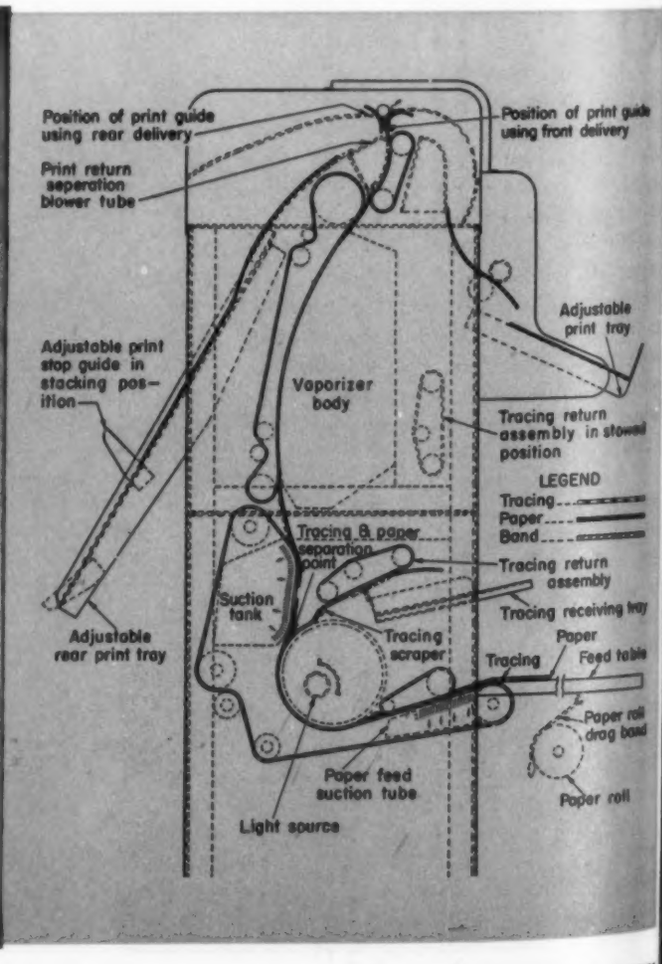
Whiteprinter Production Is Increased

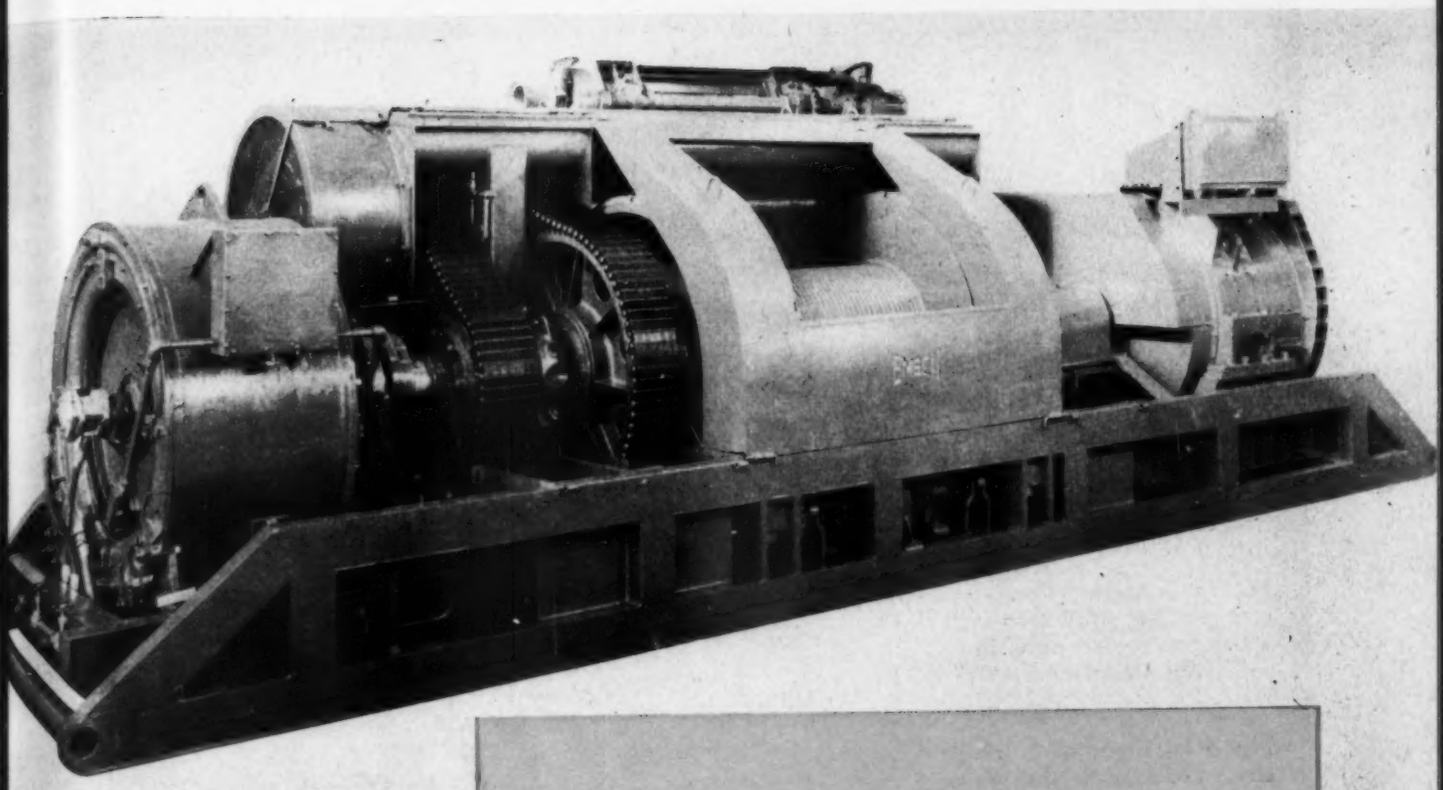
COMPLETELY new continuous automatic Whiteprinting machine, the C. F. Pease Co. Pacemaker, below, is designed for both printing and developing ammonia type whiteprints from cut sheets or rolls at speeds to 32 feet per minute. A cross section drawing through the machine, which handles material up to 42 inches wide, is shown, below right. One unusual feature is the adjustable contact device, which enables the operator to select either sliding-revolving contact or straight revolving contact between paper and the light drum, whichever is most desirable for the particular type and size of work being reproduced.

Separation of tracings or original copy from the sensitized material is automatic, with exposed prints being conveyed into the developer section while the original is returned for additional feeding. At the separation point, the traveling belt is carried over a suction tank where the paper is pulled from the tracing by vacuum in the tank.

A scraper peels the tracing from the revolving light drum and delivers the tracing to the receiving tray. Instantaneous and positive speed control is provided through a GE Thymotrol drive and additional adjustments in exposure time can be obtained with a light shutter.







Chain Drive

. . . employs new engagement principle to eliminate chordal action

Fig. 1—Above—Chain drive enabled Emsco Derrick & Equipment Co. to construct the first portable diesel-electric oil rig, capable of drilling holes to 20,000-foot depths and operating twice as fast with loads three times those previously considered possible

OPENING broad new fields of application, a revolutionary power transmission chain drive employing new design principles has been developed by the Morse Chain Co. It provides a power transmitting medium that combines the dependability of a gear drive with the smoothness of a belt. Single drive units are capable of transmitting as much as 5000 horsepower at linear speeds up to 6500 feet per minute or rotative speeds up to 3600 revolutions per minute. One chain drive, two inches wide, has transmitted as much as 500 horsepower.

This chain, called Hy-Vo, emerged as a result of a new design for a 1500 hp, 600 rpm, electric-powered, portable oil drilling rig which required a power transmission drive beyond the capabilities of any in existence at the time, *Fig.* 1.

Secret of performance is a chain-and-sprocket engagement principle that virtually eliminates what is known as chordal or polygon action common to the usual chain drive, *Fig.* 2. This bumping, slapping, jerking action and vibration eventually fatigues a chain, leads to drive failures, and generally shortens chain

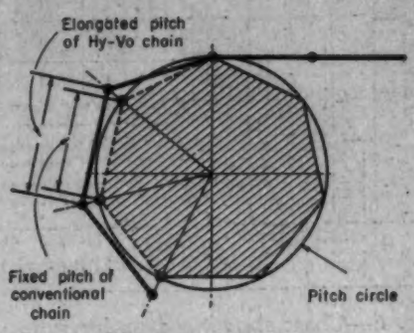


Fig. 2 — Elongated pitch of articulated chain wraps sprocket outside of the pitch circle, while conventional chain wraps sprocket inside

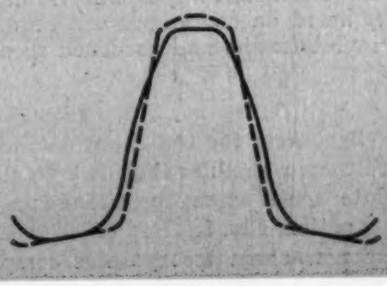


Fig. 3—Solid line shows contour of sprocket tooth, while the superimposed broken line indicates the outline of a standard silent chain tooth

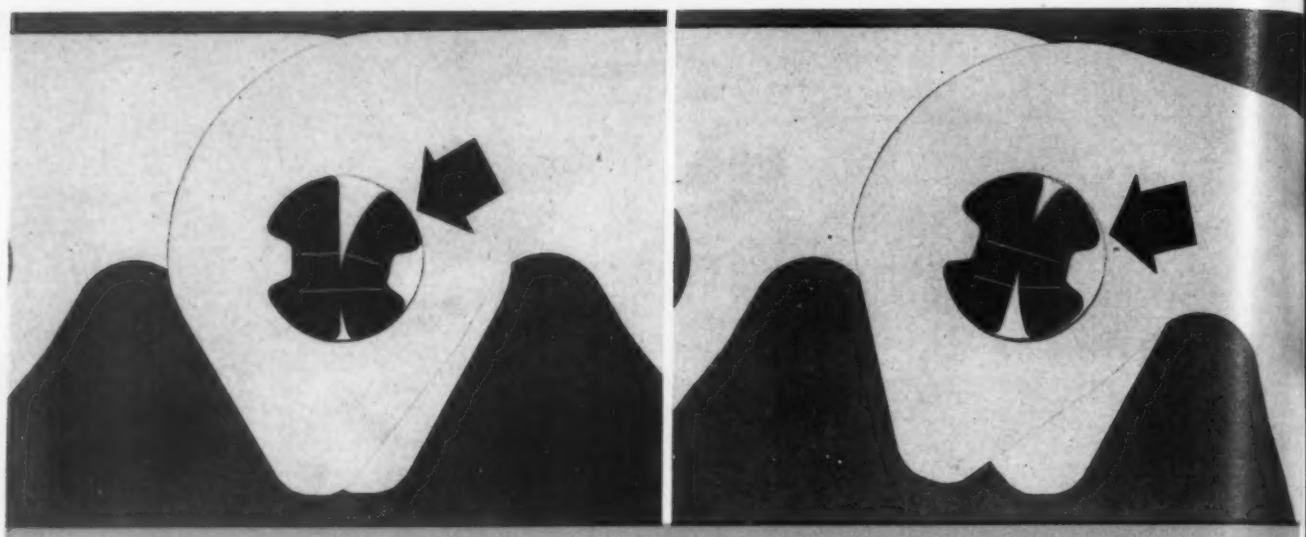


Fig. 4 — Above—Compensating rocker joint showing action of rocker pins during articulation

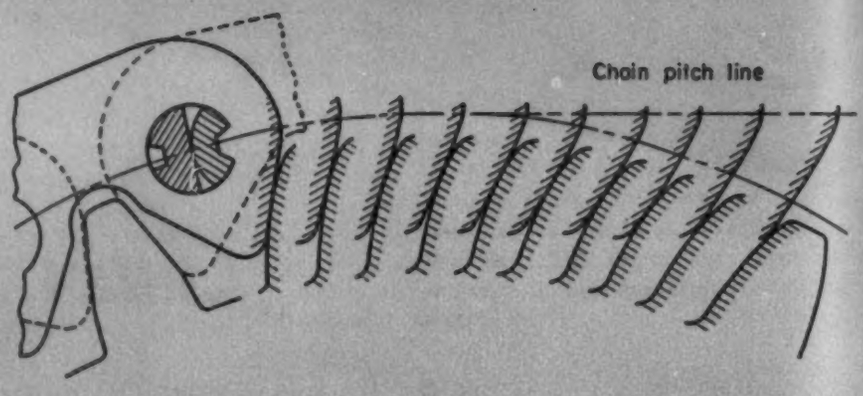


Fig. 5 — Right — During chain articulation, the joint shifts the pitch line automatically as the chain engages the involute sprocket teeth permitting the chain to follow a path truly tangent to the pitch line

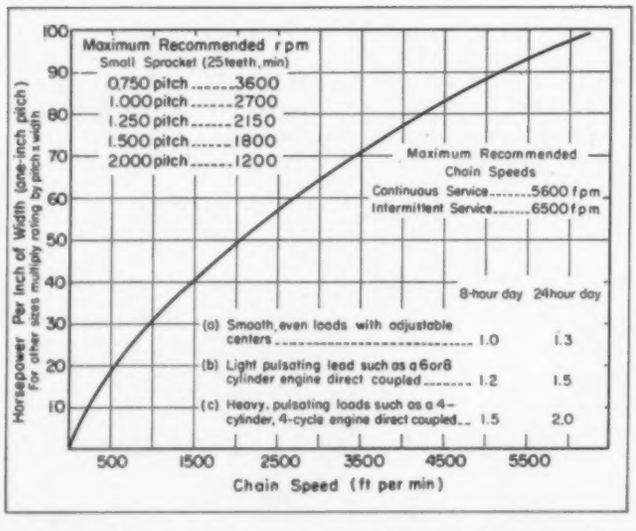


Fig. 6—Chart showing capacity rating of Hy-Vo chain drives based on continuous service with pressure spray lubrication and hardened sprocket teeth

life. Sprockets for the chain also are new in design. Tooth form resembles that of involute gears, a curved involute tooth engaging the chain links with conjugate action, *Fig.* 3.

The new chain incorporates compensating rocking joint with special design features for eliminating slippage and wear, *Fig.* 4. During chain articulation, the joint shifts the pitch line automatically, engaging the involute sprocket teeth in such a way that the chain follows a path truly tangent to the sprocket pitch line, *Fig.* 5. The result is a smooth, almost vibrationless action. Pitch elongation or "stretch" has been eliminated to the extent where it is virtually unnecessary to provide any means of take-up for the chain.

At high chain speeds, working loads twice as great as those normally used can be applied during sustained operation. This is due to the elimination of the chordal action that usually limits working load and maximum rotative speed. With full loads at any speed, the drive is extremely quiet, runs cool at all speeds and has an efficiency of over 99.5 per cent.

This chain in no sense replaces present roller or silent chain drives, but supplements them. It is designed specifically for speed applications higher than those possible with conventional chain drives. A 6-inch Hy-Vo drive, for example, will do the work of a 24-inch belt. A general idea of chain capacity can be gathered from the chart in *Fig.* 6, which gives horsepower and speed values.

At present Hy-Vo drives are being produced in one-inch, one-and-one-half inch and two-inch pitches, in the most commonly required chain widths.

PRODUCTION AND DESIGN
Modern Practices in Manufacture

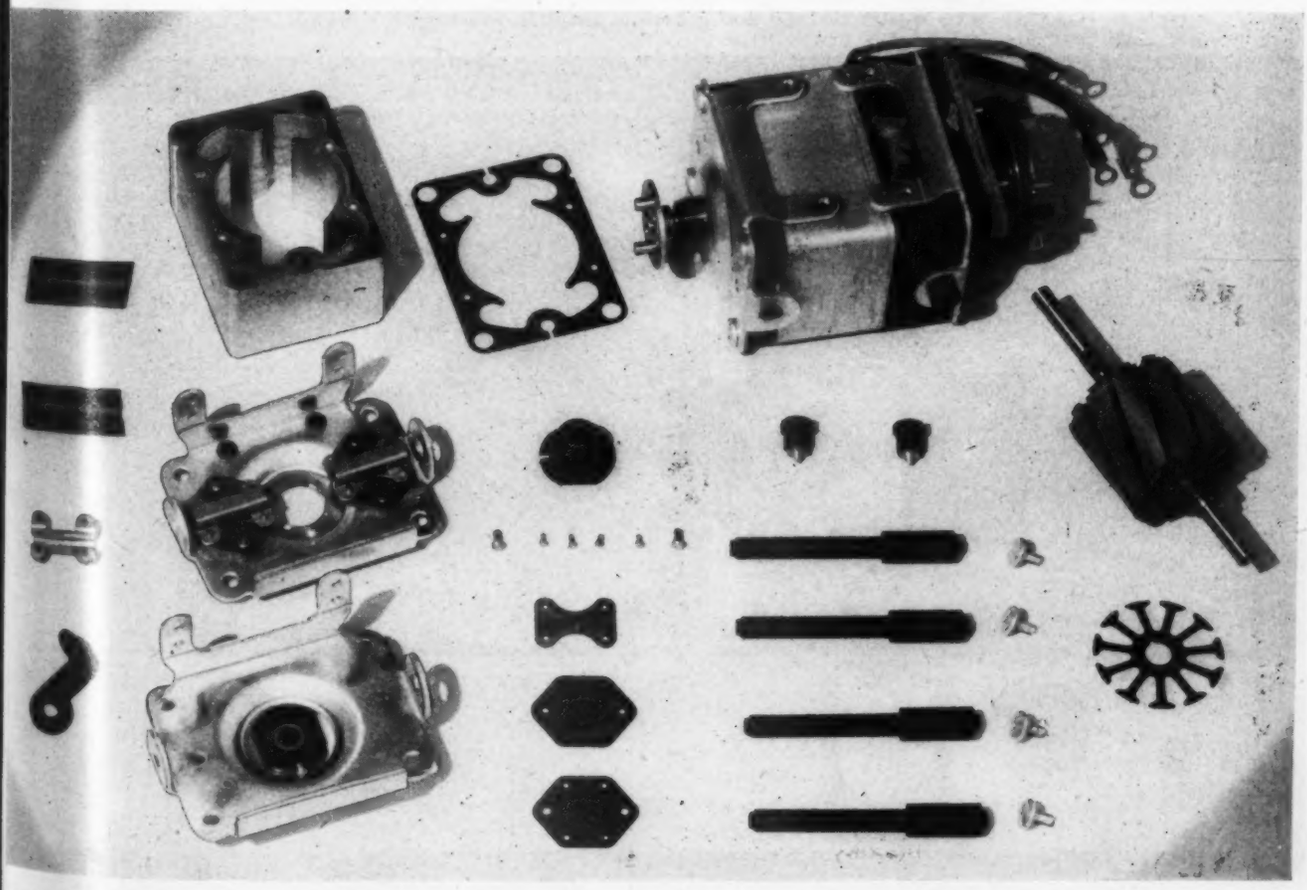
Designing a Motor For High Production

By John L. Moody
Research Engineer
Friden Calculating Machine Co.
San Leandro, Calif.

DESIGNERS of office machines must design, redesign, and conceive continually to lower the cost of machines that have become so highly competitive that low initial unit cost is mandatory. To achieve this end, good design for production is imperative. The motor shown in *Fig.* 1 was designed by engineers of the Friden Co. almost entirely of punch press and screw machine parts.

It was necessary, of course, that the motor be designed so that there would be a minimum number of parts. Also, the parts had to be kept as simple as possible to expedite tooling. The first problem was

Fig. 1—Redesigned motor and component parts. Simplicity, interchangeability and savings in materials were enhanced by improved performance



the design of a sturdy fabricated frame. Sufficient strength was required to hold the field lamination assembly and front and rear bearings closely enough to maintain an air gap of 0.015-inch between the inside diameter of the field laminations and the outside diameter of the armature.

As is obvious from the illustration, the two end plates of the motor are identical sheet-metal parts made by one blank-and-pierce and one form-die operation. The end plates are held together by four automatic screw-machine tie rods which also serve to maintain the field lamination assembly in place by passing through reamed holes in the lamination assembly. To eliminate line reaming the bearings for the armature shaft, the bearings were pressed into small housings and the housings in turn pressed through openings in the end plates. This gave the effect of self-aligning bearings, eliminating the costly operation of assembling the main case with the two end shields and line reaming before completely assembling the motor.

Composite Design Employed

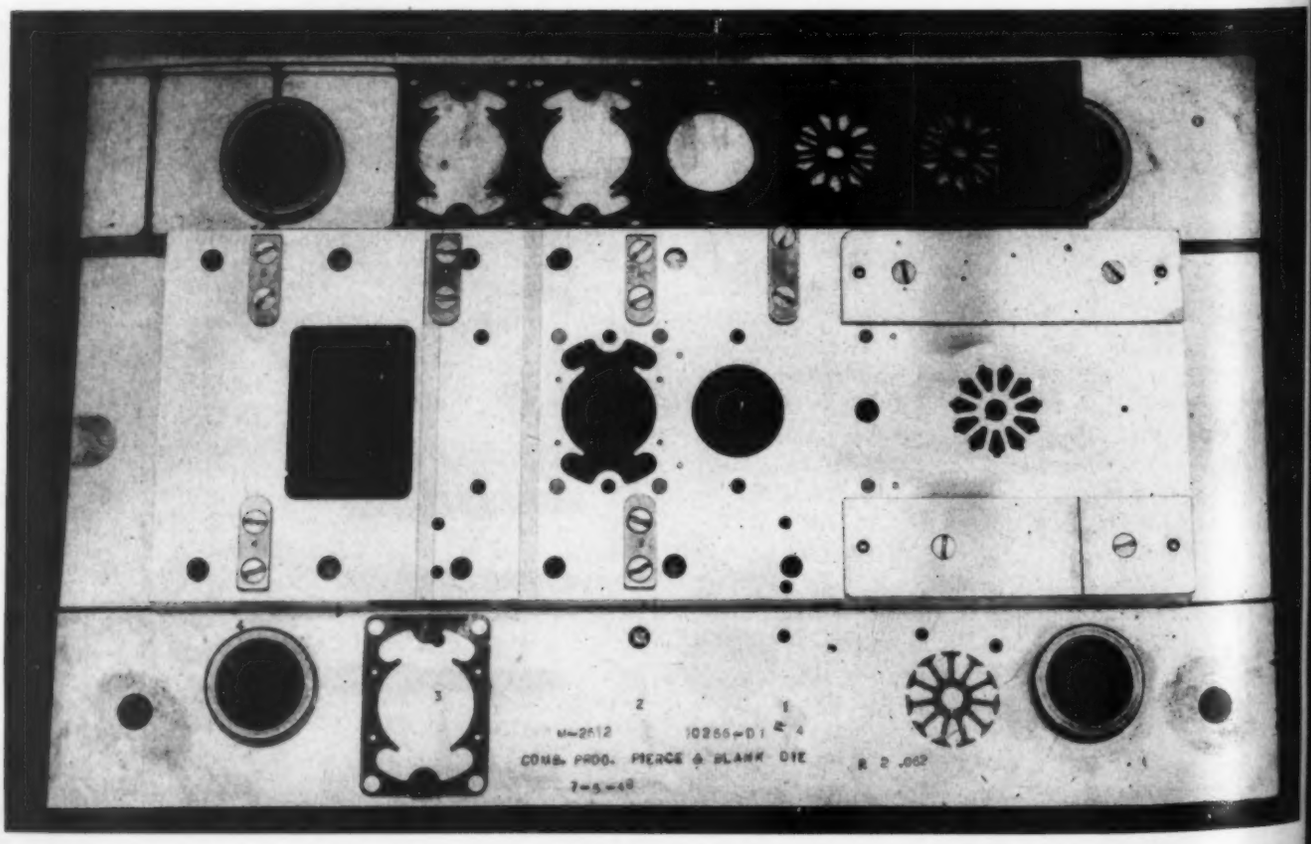
The problem of fastening the motor to the calculator base was solved by forming on the end plates ears with die-pierced holes which are later tapped. Since the hole locations had already been established by motors formerly used and were not equidistant from the ends, each end plate had to be made with two sets of holes so that all end plates could be produced as identical parts by the same die. Formed ears also were used to accommodate the commutator brush caps, even though on one end plate the ears are not required. The brush holders are formed from 0.032-inch sheet brass and are riveted to the rear end plate with suitable insulation.

Improved Operation Obtained

Armature and field laminations are made simultaneously in a six-station combination progressive pierce-and-blank die, as shown in *Fig.* 2, from 0.025-inch silicon-steel strip stock. The die, made of a high-carbon, high-chrome steel, will run approximately 90,000 pieces before resharpening. Each press stroke produces one armature and one field lamination and 11,000 complete sets are produced per hour. The six stages of progression can be observed readily from the partially finished strip shown silhouetted against the upper portion of the die in *Fig.* 2. The armature lamination is completely finished in the third progression while the field lamination is not finished until the sixth.

In addition to reducing the overall cost of the motor, critical materials are saved and production enhanced. Of equal importance, however, is the distinct advantage gained from this type of motor design. Heat-rise tests proved that the open construction made it possible to dispense with a cooling fan, which further reduced the original materials, fabricating and assembly cost.

Fig. 2—Pierce-and-blank die employed and strip showing progression to field and armature lamination on each stroke



MACHINE DESIGN
A PENTON PUBLICATION
JUNE 1951

EVALUATING ENGINEERS

. . . to recognize talent and reward achievement

By
Randolph W. Chaffee
Consulting Engineer
Kenneth A. McIntyre Associates
Cleveland, Ohio

A discussion of methods for job evaluation and merit rating in creative engineering



EVALUATING ENGINEERS



". . . for evaluating creative engineering it becomes necessary to reach out beyond the horizon of repetitive work . . ."



WHILE the present rearmament program of necessity requires considerable creative engineering talent, it is equally important that all key industry engineering staffs be kept intact. The creative engineer can make his contribution just as effectively, and in some instances moreso, in his normal employment environment. Being accustomed to the uncertainties and fluctuations commonly encountered in creative engineering, however, design engineers may be attracted by higher pay, leaving their erstwhile employers without adequate or trained engineering staffs.

Sound job evaluation and merit rating properly employed in creative engineering may provide the answer for, when the engineer's normal employment environment includes fair recognition of his talents and accomplishments, he is much less likely to be responsive to temporary higher pay. In these days of emergency and those which lie ahead the condition of greater stability in creative engineering employment so promulgated will assume tremendous importance. The unnecessary pirating of creative talent, too, will be eliminated.

TRADITIONALLY, the inevitable reward of ability and effort in creative engineering has been technical achievement, pride of authorship and eminent repute in the engineering fraternity. The engineering apprentice entered into a hallowed realm and gladly endured material sacrifice for the privilege of basking in the reflected glory of established practitioners.

Today, to use a contemporary term, "that's the bunk." When a common bricklayer commands a protected income of $6000 per year, the potential engineering apprentice asks himself why he should invest many thousands of dollars and years of his time in preparing for a lowly engineering job paying half that much—provided the variables in the work allow him to keep working 12 months every year. The 1950 enrollments in our engineering colleges give emphatic point to that question.

The time has passed when the apprentice engineer can embark upon a career with any assurance that ability and effort will win recognition. Creative engineering has been subdivided, specialized and slotted. Each job falls into a nebulous and undefined bracket and there is rarely a vertical connection between brackets. Advancement from one bracket to the next higher is more a result of chance, favoritism or showmanship than of pure merit. It is easier to keep the good draftsman on the board and to hire in a new designer, than to help the draftsman advance himself. Even the older and more experienced engineers have been moving from job to job with alarming frequency, during recent years, in pursuit of a fair opportunity to win recognition.

Rare indeed is the engineering organization which "spells-out" in clear and understandable terms, the qualifications required to fill jobs or to win promotion. Still more rare is the engineering organization which makes an honest effort to assess the talents of its staff, to assist its staff members to develop the talents required for promotion, or to make promotions solely on the basis of merit.

It's a lot easier to "grease the wheel that squeaks the loudest."

True, some progress has been made in the qualitative development of engineers. Advanced formal education is being encouraged, here and there, by sharing of the costs of tuition and textbooks by management. Discussion groups, circulation of engineering journals, subsidized memberships in technical societies, captive lecture courses, and many other devices help a great deal and these efforts merit praise and support.

Nonetheless, these devices fall short of the target. They depend largely upon the initiative of the individual to respond to their appeal and they cannot relate themselves specifically to the needs of the individual or his job. They ignore, largely if not completely, personality deficiencies of the individual such as the instinct for responsibility, abilities to organize and correlate the many facets of creative engineering, technical integrity, objectivity, and many other vital qualities. Something is needed which looks deeply into the individual personality to disclose the missing links and which joins forces with the individual to supply those links.

Impact of Job Evaluation: Probably no single instrument has made a deeper impression upon industrial and commercial society than the related arts of analyzing, classifying and evaluating jobs, and of assessing performance on jobs. Many fumblings inevitably plague the new approach in human relations. Nevertheless, job evaluation, to use the common composite label, has given to superior and subordinate

alike a practical yardstick and terminology by which to understand each other. This is true between foreman and laborer, the personnel department and the union, the board of directors and executive management and all others involved in labor relations. Job evaluation provides the meeting ground upon which differences are resolved by objective diagnosis. The relative importance of different jobs is defined and the range of wage rates is allocated equitably over the range of job values. Means are provided for relating wage rates in one organization fairly with wage rates in the community or industry, with consequent reduction of turnover and pirating of skilled labor.

These and other gains have won rapid and widespread acceptance for job evaluation in many areas of the industrial community where jobs are repetitive and qualifications easily isolated and assessed. More than a few union locals have demanded the protection and representation of job evaluation and have enforced their demands effectively. Few managements, if any, have found just cause to resist these demands. No enterprise in which job evaluation has been undertaken with honest purpose and executed with at least modest skill has failed to win the support of all parties to it.

Current Scope of Job Evaluation: Why, then, has this valid art not been employed in creative engineering? The answer to this question is near at hand.

The analysis and classification of jobs normally start with four factor-groups; namely, skill, effort, responsibility and working conditions. Although different labels are often applied to these groups, and the individual factors may be defined or arranged differently, it is generally agreed that repetitive jobs can be studied in these broad terms. For example: with respect to the warehouseman, typist, file clerk, drill-press operator, truck driver, and a long list of other common repetitive jobs, we can say that if the incumbent has had six months, one year or some minimum length of service, that incumbent has the necessary skill to perform a given task.

Under the heading of Effort, we can agree that a given job requires much or little physical effort, much or little attention to accuracy to avoid errors, much or little effect of errors, etc.

Repetitive jobs involve either no responsibility, or some specific responsibility for property, safety, training, supervision or contacts and we don't have to reach out very far to define a relative degree.

Job evaluation has been widely applied to repetitive jobs and has found fertile ground in this vast realm, because it is relatively easy to classify the obvious requirements of those jobs. Job evaluation has not developed in the area of creative engineering as yet because we are mentally lazy by nature and, not having been confronted by an organized demand for it, we have not set ourselves to accomplish it widely. Nonetheless, there is valid reason to extend to engineers, designers, artists, draftsmen, technicians, model builders and all other creative genii the same opportunities for recognition that has been extended to organized production workers.

How Evaluation Yardsticks Are Established

Factor Selection for Repetitive Work: The first stage in a job evaluation program is the selection of the factors which will be used to analyze and classify jobs. Each factor will be used as a yardstick to measure one essential quality required to fill a job. Each quality must be definable in reasonably exact and clear terms, and its definition must not overlap or encroach upon the definition of another factor or quality.

Factors differ in their relative importance, and the factor yardsticks are of different length. However, the same yardstick is always used to measure the same factor, and the same measure is applied to two or more which have equal importance.

NUMBER OF FACTORS: The four labels—skill, effort, responsibility and working conditions—are not enough to measure all jobs in an organization. The chief draftsman and the toolmaker use different types of skill although both may be evaluated at the same total level. However, we do not know what their skill levels are, how these skills differ or that they are of equal importance until we analyze their skills in all essential details.

The trick is to use enough factors to distinguish clearly between the essential qualifications. The trick is also not to use too many factors which tend to overlap one another so as to obscure the distinctions and to cloud the definitions.

Probably the number of factors most commonly employed in one enterprise is about fifteen where application is limited to more-or-less routine or repetitive jobs. This is not to say that the same fifteen factors with their exact definitions can be or are used in two or more different companies, but only that many organizations have found this quantity to be a successful and happy medium.

The number of factors used bears no relation to the size of the organization—mere numbers of workers do not effect the number of factors. Nor is the number of factors properly governed by the number of organization branches such as production, maintenance, administration, accounting, sales, etc. Although the view is controversial, many authorities contend that the same factors (whatever their number and if wisely selected) are equally applicable to jobs in all departments, and that the file clerk's job can be classified under the same number and descriptions of factors as the turret lathe operator.

There are two areas within which the number of job factors is properly regulated. We may agree, for example, that fifteen factors are ample for classifying all jobs within the unit or even beyond that to in-

clude junior working supervision. Above these levels, job characteristics depart from routine mechanics and approach the realm of the intangibles such as the qualities of leadership. Thus, the number of factors must increase as job classification reaches levels above junior supervision.

The area of job classification has depth as well as height. Fifteen factors may be adequate to cover many repetitive jobs but are quite inadequate to cover nonroutine jobs below supervisory level which involve research, creative development, and other obscure talents. Here again, we have to reach out for additional factors needed to recognize and evaluate the distinctive requirements of these jobs.

TYPES OF FACTORS: As a point of reference, the factors commonly used in repetitive work are described briefly in the following paragraphs.

Job Factors Comprising Skill: Factor 1 in this group, *previous experience,* relates to the breadth and duration of previous experience in similar lower jobs either within or without the given company. It is measured and rated in relation to the number of years and months of such experience that may be demanded. Factor 2, *specialized training and education,* covers the kind and degree of specialized and technical education which prepares the individual specifically to perform the work in question. It is measured in terms of the level of education and the number of years and months of such education at the stated level, viz., high school education plus the duration of specialized education in a recognized school. Factor 3 is *manual or physical skill* and covers physical skill or dexterity as in handling tools, making mechanical adjustments, etc. It is classified in terms of the complexity, variety, accuracy, and regularity of muscular motions habitually required in the job.

Job Factors Comprising Effort: In this category factor 1 is termed *physical effort.* This factor considers the muscular strain required to lift, carry and handle weights, the continuity of effort and the degree of resultant fatigue. It is classified as to ease of movement, weight of materials handled, frequency and duration of exertion, strain due to working in cramped positions, etc. Factor 2, *mental effort,* considers the variety of tasks involved, the degree of judgment to be exercised and the demand for two or more dissimilar skills in the same task. Mental effort commonly is found in reading complex blueprints, interpreting tolerances, setting machines, etc. Factor 3, termed *care and attention,* is used to classify the degree of care and attention required to avoid errors, the possible frequency of errors and their effects in damaged property, lost time and expense.

Job Factors Comprising Responsibility: Under the heading *safety* is classified responsibility for the safety of others such as fellow-workers, customers, visitors and the public. The classification considers the number of others necessarily exposed to unsafe conditions, the degree and continuity of hazards and the need for taking protective measures. Factor 2, *funds and property,* considers the degree, frequency and duration of individual responsibility for the protection and safe handling of the funds and property of others. It is measured in relation to the sums of money and negotiable documents entrusted, the frequency of handling and the related hazards. Termed *confidential information,* factor 3 relates to confidential and classified records and information necessarily entrusted. The job is classified in terms of the relative importance of information entrusted and the potential seriousness of the consequences of improper disclosure. Factor 4, *external contacts,* considers the



Photo, courtesy Allis-Chalmers Mfg. Co.

". . . Something is needed which joins forces with the individual personality to disclose the missing links and which joins forces . . . to supply those links . . ."



"... job evaluation gives to superior and subordinate alike a practical yardstick and terminology by which to understand each other ..."

Table 1—Typical Relative Maximum Job Factor Values

Job Factor	Electric Utility (Points)	Electric Utility (Percent)	Distrib. Warehouse (Points)	Distrib. Warehouse (Percent)
Skill				
Previous experience	40	8	15	3
Specialized training	40	8	10	2
Manual skill	20	4	20	4
Subtotal	100	20	45	9
Effort:				
Physical	10	2	50	10
Mental	80	16	60	12
Care and attention	35	7	30	6
Subtotal	125	25	140	28
Responsibility:				
Safety	35	7	25	5
Funds and property	15	3	90	18
Confidential information	15	3	10	2
External contacts	40	8	20	4
Internal contacts	10	2	10	2
Supervision received	20	4	45	9
Supervision given	100	20	55	11
Subtotal	235	47	255	51
Working Conditions:				
Hazards	30	6	30	6
Unpleasantness	10	2	30	6
Subtotal	40	8	60	12
Grand Total	500	100	500	100

requirement for dealing with customers, other companies and the general public, the difficulties and importance of the transactions handled and the potential effects upon the company's position. Under factor 5, *internal contacts,* is measured the volume, importance and difficulty of necessary contacts within the organization as with other departments, and the potential consequences of these contacts in relation to morale and efficiency. *Supervision received* is factor 6. This factor is used to classify the proximity and frequency of supervision received, the degree of instruction received and the basis upon which performance is appraised. The classification relates to independence of action, frequency of reporting, importance and duration of assignments and the level at which results are checked. The classification is higher as the degree of supervision received is lesser. Final factor 6 is *supervision given.* This factor relates to the direction, instruction, discipline and training of others, and to the planning, controlling and checking of the work of others. It is classified as to the number and variety of tasks, skill levels and specialized skills of the persons supervised.

Job Factors Comprising Working Conditions: First factor, *hazards,* is used to measure the health and accident risks inherent in the job. This includes the opportunities for and potential harm from exposure to falls, injury from falling objects, power tools and machinery, occupational disease, burns, electric shock, dangerous chemicals, etc., each of which are appraised as to relative seriousness. Second factor in this category is *unpleasantness.* Under this factor are considered the necessary exposures to heat and cold, dampness, noise, dirt, vibration, obnoxious odors, etc., in terms of the frequency, degree and duration of unpleasantness.

WEIGHTING OF FACTORS: All factors do not have the same importance in the same job evaluation program and the same factor will have differing importance in the job evaluation programs of different companies. Two jobs may pay the rate of $1.50 per hour, one in a manufacturing plant and the other in a motor freight carrier company, but the factors comprising skill will be more important in one while the factors comprising responsibility are more important in the other. The foregoing total group of fifteen job factors are applicable in an electric utility and a distributing warehouse, for example, in the relative maximum values shown in TABLE 1.

Thus it appears that the distributing warehouse demands less experience than the electric utility but imposes working conditions 50 per cent more adverse. Although the overall demands for effort and responsibility are not far apart in these dissimilar industries, these factors appear in different forms. Mental effort predominates in the electric utility while physical ef-



"... resourcefulness relates to the intangible capacity to find or adapt the means for creative engineering ..."

fort leads in warehousing. Also, responsibility for consigned merchandise of high value in the warehouse approximates the responsibilities for supervision in the electric utility. The 500 scale used in TABLE 1 is arbitrary. Although this maximum has served well in many companies using up to fifteen job factors, it may be too low where more factors are needed.

The foregoing has been presented to illustrate generally the level of industry-wide accomplishment in the classification of repetitive jobs, and to provide a springboard for job classification in creative engineering.

Appraising Creative Engineering Requirements

Factor Selection For Creative Work: In selecting the factors to be employed for evaluating creative engineering, it becomes necessary to reach out beyond the horizon of repetitive work and beyond the obvious characteristics of repetitive work. In addition to the common job requirements such as manual dexterity and effort we must consider the demands made upon obscure mental powers.

This "reaching-out" process is, in effect, a "reaching-down." We reach, not outward horizontally toward a more distant horizon, but downward more deeply into the intellectual and spiritual powers. We subdivide further the factors of study and evaluation to the point where we can recognize, isolate and appraise different types of obscure job demands, to the point where we can assign to them the different degrees significant in creative engineering.

This added "reach" is in territory largely unexplored as yet. However, from the few successful attempts we have learned the basic principles involved and add to the fund of experience as these principles are applied to more and more engineering organizations. In one application of job evaluation in creative engineering, thirty-four job factors were used, grouped under major headings comprising,

Skill	13
Effort	4
Responsibility	8
Inherent personal qualities	8
Application	1
Total number factors	34

The application was made in a professional engineering group where the scope and variety of objectives and responsibilities are greater than in the typical "captive" engineering organizations. The same pleasant working conditions prevailed for all jobs in the group and were unimportant for job evaluation purposes, whereas the evaluation did demand careful recognition of certain inherent personal qualities.

Method of Selecting Job Factors: Having no background of experience with job evaluation in creative engineering, the authors of this application were compelled to approach the problem with thoroughness and exactitude. The whole group involved in the application represented four broad functions; namely,

1. *Creative design* including project engineers, general and specialist designers (mechanical, electrical, electronic, chemical, structural and industrial), draftsmen, detailers, etc.
2. *Project execution* including tool and model builders, artists, analysts, process engineers, etc.
3. *Business administration* including project managers, accountants, market analysts, secretaries, stenographers, file clerks, etc.
4. *Plant and Equipment Maintenance* including janitors, mechanics, carpenters, plumbers, painters, boiler operators, electricians, etc.

It was recognized at an early point in the study that one, two, three, or four different formulae of job study, classification and evaluation might be needed for these different groups of functions. The decision on this question was deferred until a later stage.

STAGE ONE—PREPARATIONS: As a prelude, the job evaluation program was announced to the entire organization as a joint management-staff undertaking in which the staff would describe and generally eval-

uate all jobs while management would provide the media for leveling, balancing and implementing the evaluations. This approach was successful, in this case, because of the relatively high level of intelligence which must prevail among creative personalities, and it won the hearty support of the entire organization.

A job evaluation committee was formed consisting of the personnel director, the chief draftsman and the engineering administrator with the intent to bring to bear upon the program the viewpoints of management, staff and clients. This committee started the program with a thoughtful study of literature on the subject but with no previous experience or foregone conclusions.

STAGE TWO—PRELIMINARY INTERVIEWS: At least one staff member was interviewed by the committee from the highest, lowest and midlevels in each of the four branches of the enterprise. These interviews inquired into the facts of the qualifications of each staff member interviewed, apart from opinions, in an effort to get at the talent actually employed at each of these levels. Specifically, in respect to the particular talents of the staff members and the demands made upon by their jobs, the answers to these questions were sought:

1. What different talents do you possess and employ in your work?
2. What tasks demand of you the greatest, least and most common degree of each of these talents?
3. In those talents in which you believe yourself to be least qualified, what degree of improvement do you feel to be needed to complete your fitness for your work?
4. In those talents in which you believe yourself to be best qualified, what degree of your ability is not utilized?
5. With respect to each talent which you possess, what additional degree of qualification do you believe is needed to equip you to fulfill the requirements of the job just above you?
6. With respect to the demands made upon you in the next lower job, what additional degree was required for you to become qualified for the job you now have?
7. With respect to the talents you possess, what jobs in the other three branches of the enterprise do you believe demand the same maxima, minima and average degrees which your job demands?
8. From the standpoint of talents displayed, what individuals in the organization do you consider best qualified for the jobs just above and just below your job?

It will be obvious that the purpose of these questions was to draw upon the intimate knowledge of the working incumbent for "pegging" himself in relation to other jobs and incumbents, and to setup reference-points from which the departure of all jobs might be measured.

At first sight, the answers to these and many like questions produced an unintelligible hodgepodge of response, including large measures of opinion, prejudice and pride. When taken as whole, however, with opinion discounted and fact emphasized, a logical pattern of job relationships was found without undue difficulty.

STAGE THREE—DESCRIPTION OF JOB FACTORS: Responses to the preliminary interviews led to a qualitative analysis of required talents and enabled preliminary descriptions to be written of the necessary job factors. The whole list, which includes a number of factors common to any job evaluation formula plus others peculiar to creative engineering, was finally clarified under the four major headings of skill, effort intensity, responsibility and inherent personal qualities.

Skill: Eleven factors were found necessary to identify, classify and evaluate the several types and components of skill required in creative engineering. Two of these eleven factors were subdivided into two parts each, as described in the following paragraphs.

1. The composite factor, *academic training,* refers to formal schooling in recognized educational institutions including grade school, high school, collegiate and post-graduate levels, night schools, trade schools, correspondence schools, and in-service educational programs. In order to recognize the important distinctions between technical and nontechnical training, and their relative importance in the enterprise, it was necessary to define liberal education separately from technical education.

2. The second composite factor, *in-service experience,* refers to practical working experience in terms of type, caliber and duration demanded as preparation for the job. In the application herein described, variety of experience is more important than intensity of experience and it was necessary to distinguish between in-service experience in "this occupation (professional engineering) and in "this company". The thinking here was that a designer with prior experience with the wider varieties of creative projects of other professional groups, including his own independent projects, is more broadly productive than the designer with experience in one group only.

3. The factor, *resourcefulness,* relates to the intangible capacity to find or adapt the means for creating. Neither pure research nor invention is involved here but rather the ability to select basic established art and to adapt that art to the problem at hand. To illustrate, the basic science of nuclear fission for the transformation of matter into energy has been understood in theory for many years. To find the practical means to cause and to control this transformation called for tremendous resourcefulness.

4. The creative engineer may attack his problem in either of two ways. One way is the "cut-and-try", starting with no clear notion of the final approach and letting the approach develop itself as trial-and-error succeeds trial-and-error. Until recent times, this was the common way as well as the only way open to many, and many of our great industrial empires built their foundations upon "cut-and-try" engineering. It is not to be discredited where it is the only way open. Unfortunately, "cut-and-try" is time-consuming and costly. The better way employs the *power of visualization* to determine not only the end result but also the avenue of approach to that result, with a mini-

mum of uncertainty and tolerance for error. It is a form of the old story that "a little headwork saves a lot of footwork."

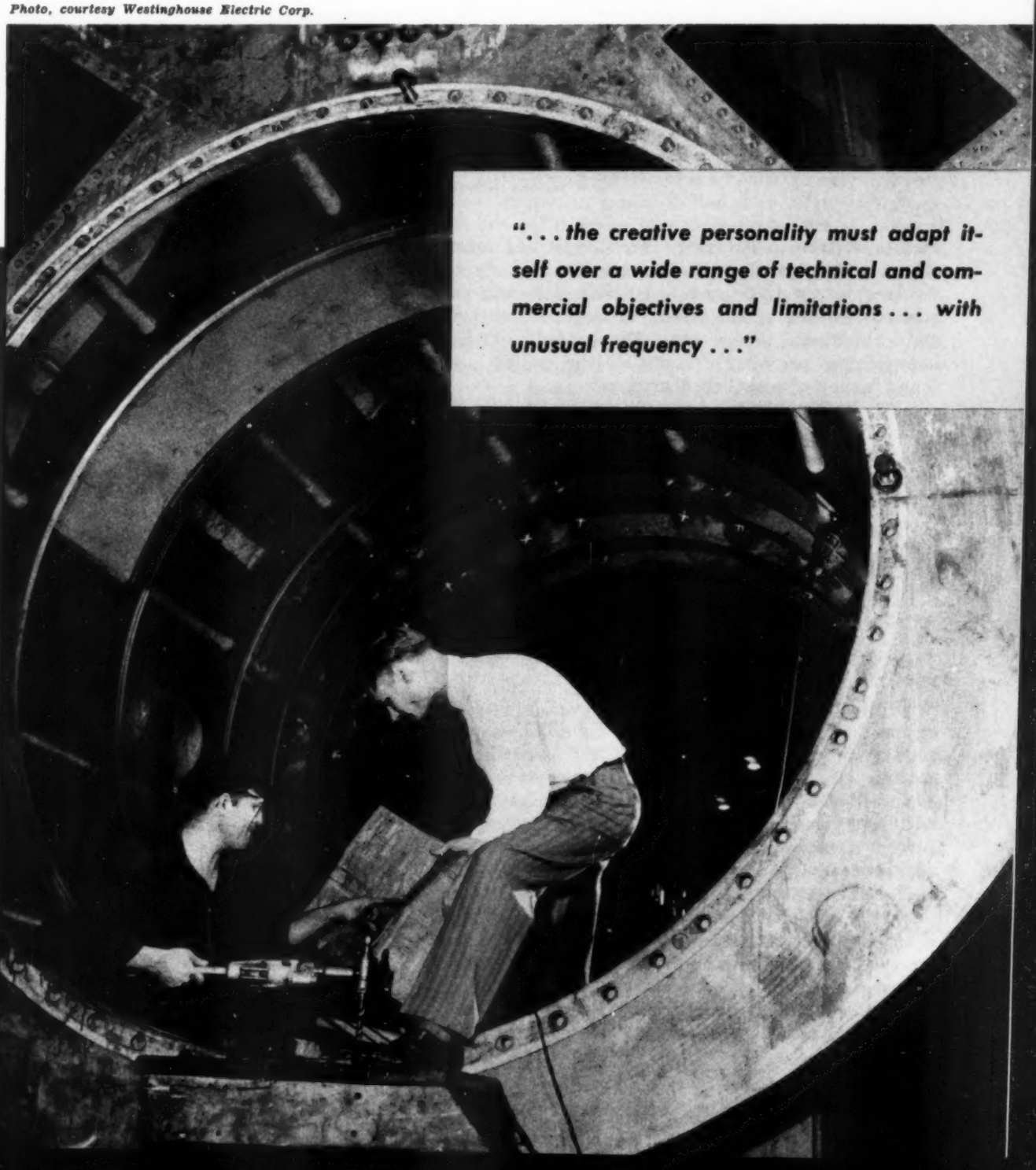
5. In repetitive work, *adaptability* generally refers to the capacity of the individual and the demands of the job on this capacity to adapt to the product, environment, organization structure and working conditions—a process which occurs once when the incumbent enters the company's employ or infrequently when the incumbent is transferred or promoted. This process of adapting is essentially spiritual and involves largely the ability to "get along with others."

The creative personality must adapt itself over a wide range of technical and commercial objectives and limitations to every project anew and the transition occurs with unusual frequency. The creative engineer may be involved at one time in the complex art of heat treating nonferrous metals, and next in the design of a cheap die-cast ornament to be produced in vast quantities and merchandised at a low retail price. While extreme, these samples illustrate the demand upon the creative designer for quick and frequent reorientation of approach.

6. Another obscure factor that is difficult to isolate and appraise but which must be recognized in evaluating creative tasks is *analytical power*. While frequently mathematical in character, analysis in creative work involves the broad sorting of fact and fancy objectively so as to reject the wrong and accept the right. The objectivity of creative engineering is distinguished from the emotional approach, as in merchandising or the liberal arts, more by true analysis than by any other factor.

7. A more tangible and measureable factor, *knowledge of prior art*, relates to scope of practical experience with specified industrial arts such as optics,

Photo, courtesy Westinghouse Electric Corp.



"... the creative personality must adapt itself over a wide range of technical and commercial objectives and limitations ... with unusual frequency ..."



Photo, courtesy General Electric Co.

> "... creative engineering has become a highly complex operation involving the diverse talents of many people who must be scheduled, supervised, co-ordinated, reviewed, and fitted nicely into the project ..."

sonics, electronics, chemurgy, metallurgy and many others. This knowledge comes also from study of recorded art in trade and technical papers and periodicals, patent specifications, catalogs, expositions and exhibitions, theses, etc. The evidence of the knowledge of prior art of many creative engineers is found in their own published writings.

8. The factor, *ability in organization,* relates to the organizing of engineering work, both for performance by self and by others. Creative engineering has become a highly complex operation involving the diverse talents of many people who must be scheduled, supervised, co-ordinated, reviewed and fitted nicely into the overall project. The process requires planning, delegation of responsibilities, charting of performance and appraisal of progress if the time and money invested in the project is to yield the maximum benefit.

9. The creative engineer must be able to express himself clearly, logically and accurately, verbally and in writing. This factor, *power of expression,* also indicates he must be able to state his questions and learn from the answers, to instruct his assistants, to counsel with his associates, and to confer with his superiors. He must be able to prepare and edit his written reports and to edit and appraise the written reports of his assistants. He should be competent to address large groups, technical societies, customers' trade associations and groups of students-in-training.

10. The common description of the factor, *personality,* applies in creative work more universally and more significantly than in repetitive work. Creative engineering is now recognized to require a degree of salesmanship for the reason that acceptance of the engineer's product rests, in large measure, upon the layman's faith in the engineer as an individual. Upon the engineer's personality, as well as his reputation, rests the acceptance of his product.

11. A manual quality, *dexterity* is employed largely by shop technicians but also to a considerable extent by creative engineers in examining, operating and testing mechanisms. This dexterity includes not only handling in the usual sense and the co-ordination of the hand with the eye, but also the ability to adjust delicately and to interpret the sensations of touch, heat, motion, vibration, roughness, etc.

Effort Intensity: In keeping with the established pattern, job evaluation for creative engineering recognizes the demands made by the job upon the incumbent for the expenditure of effort. Although manual effort is one type found in this area, three other forms of mental effort are also recognized for their great importance.

1. The factor termed *mental* relates to the effort expended to study, analyze and comprehend in the larger sense that which is tangible and capable of being stated. This expenditure of effort is complementary to the factor *knowledge of prior art* insofar as lack of such knowledge requires study of prior art

in order to increase that knowledge. As the creative engineer advances in his profession, his knowledge of prior art increases while his expenditure of mental effort in study decreases.

2. The factor *mental-visual,* relates to the effort required to be expended to create, in the literal sense, the clear mental concept not only of the end result of the project but also of the approach to that result. It also relates to the effort required to detect, clarify and comprehend that which is intangible and incapable of being stated. Effortwise, this factor far outranks all other factors, in both importance and difficulty, in the job evaluation formula.

The expenditure of mental-visual effort is continued over the whole creative span of the project, occupying nearly the whole of the engineer's capacities at the outset and diminishing as the number of unsolved problems are reduced with the advancement of the project. In general, this factor is the complement of the skill factor *power of visualization* in that the mental-visual effort develops the power of visualization, and expenditure lessens as the power increases.

3. *Accuracy* in creative work includes not only adherence to established standards but also, in many cases, formulating those standards to fit the purposes of the project. Literally, 100 per cent accuracy being practically unattainable or uneconomic, judgment must be applied in selecting or creating the standards of accuracy which should apply. Creative engineering makes a substantial demand for the application of effort to achieve and sustain suitable standards of accuracy.

4. The *manual* factor applies to technical shop jobs in experimental construction which involve working in cramped positions, reaching, holding and like operations to which the technician does not become accustomed by repetition. While not wide, the range of manual effort demands recognition in different jobs.

Responsibility: All members of a creative engineering force bear definite responsibilities which generally are heavier than the responsibilities in other fields of endeavor. Even the lowliest positions on the force carry goodly measures of responsibility, if only as the result of exposure to the work as an incidental to their assigned duties.

1. Unlike repetitive work, creative engineering in the professional area involves *formulation of policy* affecting the conduct of the individual project and generally new policy is formulated for each different project. Policy is formulated in varying degrees at several of the upper levels in the project group and this factor requires independent recognition.

2. Each creative project is, in effect, a separate and detached undertaking which carries its own supervision. Each level in the group exercises supervision over the next lower level by instructing on work methods, and checking the results accomplished. The evaluation for *supervision given* in the administrative, maintenance and shop forces follows a familiar pattern.

3. The lion's share of *training* in creative engineering is on-the-job training given by the superior to the subordinate in terms of the work at hand. This training may be formalized by conferences, written tests and reports and other means of judging the trainees' response. The responsibility for this training is present in varying degrees at all levels of creative engineering.

4. Engineering personnel are assembled into a group for the duration of the engineering project and then disbanded to make this personnel available for other projects. In this area of *personnel requirements* the reponsibility for wise selections of individuals and skills is a heavy one and it is often shared between two or more leaders in the project team.

5. Repetitive work frequently enables the use of fixed standards for measuring individual performance as the basis for promotion, transfer, demotion or separation and the process of measurement seeks a fair and objective result. The extreme diversity of assignments in creative engineering preclude the wholly objective appraisal of individual merit, particularly when the individual is on one job under one supervisor for a long period and a comparative appraisal cannot be obtained on that individual from another supervisor. Therefore, the responsibility for *personnel status* rests within the project staff and it demands recognition in the job evaluation formula.

6. Following the established pattern regarding *company property,* job evaluation in creative work recognizes responsibility for the use and care of assigned tools, costly materials, blueprints and reference data, and other objects normally used in performing assigned work, including confidential information.

7. In addition to physical *client property* such as models, samples, materials, instruments, etc., which may be loaned by the client, the professional engineer bears a responsibility for the confidential handling of trade secrets and of classified information within the meaning of Federal security regulations.

8. Creative engineering works with untried industrial art which contains many undefined and unmeasured hazards to *health and safety,* not only of the persons assigned to the project, but also to other persons within the zone of exposure. Project personnel must assume responsibility for the taking of adequate safeguards for themselves and others and for the prevention of unnecessary hazards.

Inherent Personal Qualities: In addition to qualifications of education, experience and the like, creative engineering demands certain inherent qualities which govern the individual's instincts.

1. The *self-confidence* factor is important in creative engineering, partly as an indirect indicator of other qualities required which are difficult to assess such as *ability in organization, power of visualization* and others. This quality also suggests the degree of assurance which the incumbent must employ to influence clients, superiors, associates and subordinates.

2. Technical perfection is unattainable or uneconomic in the creative project and reasonable standards of perfection must be set up which fit the requirements of each project. This requires an inherent instinct or *respect for perfection* which goads the engineer on until practical perfection has been

achieved but warns him against overreaching that target and wasting time and money.

3. All creative effort is subject to criticism that is unsympathetic in many instances. *Capacity to receive criticism* is important in creative work. An unemotional, impersonal and objective attitude is needed to withstand criticism, to ignore that which is unfounded and to profit from that which is useful.

4. The ethically honest engineer places his profession and his responsibilities above self and pride of authorship. *Ethical honesty* compels the creative engineer to persist in seeking the best solution, to examine himself and his product impartially, to acknowledge his errors and to admit the superior judgment of others.

5. That abstract virtue which leads men to be truthful, to respect the rights and property of others and generally behave as a respectable member of society is here recognized as *spiritual honesty,* apart from ethical honesty which relates to his professional behavior. Spiritual honesty is vital in the creative engineer who is entrusted with valuable tools, confidential information and a voice in the reputation of his associates.

6. Many creative projects are started late, under the pressure of competition, with limited working capital and demand an early "deadline." Noteworthy powers of *endurance* are needed to work under pressure for extended periods while preserving perspective and clear vision.

7. To keep focused upon the job at hand, particularly in a distracting environment, and to keep a clear view of the important objective despite tempting side issues involves well-developed powers of *concentration.* The creative engineer must keep his sights fixed on the target and permit nothing to distract him.

8. The *co-ordination* factor relates to co-ordination of mental with physical powers, and to the ability to translate mental concept into physical dexterity and vice versa. This faculty is required in artistic rendering, photo retouching, minute adjustment of delicate mechanisms, etc.

Application: Most mature engineers apply themselves to their projects from habit and keen interest in their work. Younger engineers who are prepared to apply themselves diligently should be selected and their application intensity should be assured.

SUMMARY: An unfortunate tendency, particularly on the part of those of us who are inclined to be mentally lazy, is to dismiss many of the foregoing factors as academic, intangible, impractical, and unmeasureable. We like to deal with that which is definite, clearly visible, immediately understandable and nicely within our individual spheres of experience. Frankly, it is hard mental work to sort out such obscure factors as many of the foregoing, to set down simple definitions for them, to recognize them in others, and to set up the means for measuring the degree of such factors which is demanded in the many creative engineering positions. However, even the earliest experiences with job evaluation were difficult and the present level of success was achieved only after some onerous "skull practice". Continued effort will bring equally successful application of the proved principles of job evaluation to creative endeavor.

Ranking Engineering Jobs

Weighting of Selected Factors: Having no tailor-made formula for the weighting of the selected job factors, to reflect their relative importance, the job evaluation committee for this application could only use the "cut-and-try" method. However, the second round of interviews with staff members at the lowest, highest and median levels in each branch of the enterprise showed an interesting unanimity of opinion on the relative importance of the thirty-four job factors in the eleven departments.

Prior to the job analysis, job titles were found to be indeterminate. They did not indicate, in all cases, the character of work involved in the job nor did they suggest the level of the job in its channel of promotion. Gaps were found in these channels where no titles had been provided for intermediate steps and there was no way to identify many intermediate jobs. Following correct titling of all jobs in each channel of promotion, the organization contained seventy-eight jobs distributed between the eleven departments as follows:

Product development	6
Machine development	2
Engineering design	11
Industrial design	8
Electronic development	7
Tool design	9
Experimental manufacturing	8
New products research	1
Administration	10
Personnel, purchasing and maintenance	7
Total	78

Twenty-six of these seventy-eight jobs had not previously been defined and were created to "round out" the organizational structure.

ASSESSMENT OF RELATIVE FACTOR IMPORTANCE: It was agreed, at the outset, that a maximum job value of 500 points would be inadequate and would lead to too many decimal values, and that 1000 points should be the practical maximum. This decision was revised at a later stage to use 1200 points as the maximum, to provide means for rewarding outstanding merit.

During the second round of interviews with staff members it was noted that these people rated the relative importance of their jobs, and the jobs just

above and just below their respective jobs, in terms of "average", "below average", "above average", "maximum", "minimum" and "no importance." These terms indicated that the staff would naturally recognize five levels of relative importance for each factor. The opinions given by the thirty-three interviewees in the second round were analyzed and the factors were ranked in relative importance from maximum to minimum in the general order shown in

RANKING OF FACTORS: The next decision to be reached dealt with the progession in relative value from the factors in one rank to the factors in the next lower and higher ranks and this progression could be either arithmetic or geometric. That is, the steps between ranks could be equal, or they could become either larger or smaller in the progression from one rank to the next. In the opinions of the thirty-three interviewees, upward job progression in the organization, and in all of its departments, involved rapidly widening horizons and accelerating job requirements. This opinion resulted largely from the fact of expanding industrial art, types of clients, varieties of markets to be served by the products developed and range of limitations imposed, in the area of professional creative engineering. Thus a geometric system of progression of relative job values was indicated.

In the simple geometric progression, the midreference point is one-third the range from least to greatest, and in the application here described, was found by dividing the thirteen ranks into one-half the maximum point value or 500. The quotient was the maximum point value for the job factor at midrank, namely 30. For convenience, the departure from this midrank value was made in steps of five points to the next two higher ranks and to the next three lower ranks. The progression was increased by another five points between the fifth and fourth ranks and between the fourth and third ranks and by a third increment of five points between the third and second ranks.

The geometric progression was accentuated beyond these limits to give certain special emphasis at the top and bottom of the scale. The effort intensity of mental visualization so far outranked the next most important factor that it was given one-third more points or 25 above that second factor, and this was later increased to a step of 35 points. The minimal values of the job factors in the twelfth and thirteenth ranks were dropped by only one point each to avoid under-emphasis of those job factors. After considerable weighing, discussion, testing and trial-and-error, the maximum point values for the thirteen ranks of factors were fixed as shown in TABLE 3, based upon the 1200 point total.

These methods of ranking job factors and of arriving at their relative importance in terms of maximum point values are unorthodox. Probably the point values could not be "proved-in" by any established job evaluation formula. Further, values could not be determined by these methods in any other enterprise even of like character nor could these values be applied verbatim in any other enterprise. Nonetheless, they were applicable in the organization where they were used and they are of interest largely as reflections of the type of original creative thinking that is demanded of job evaluation in creative engineering.

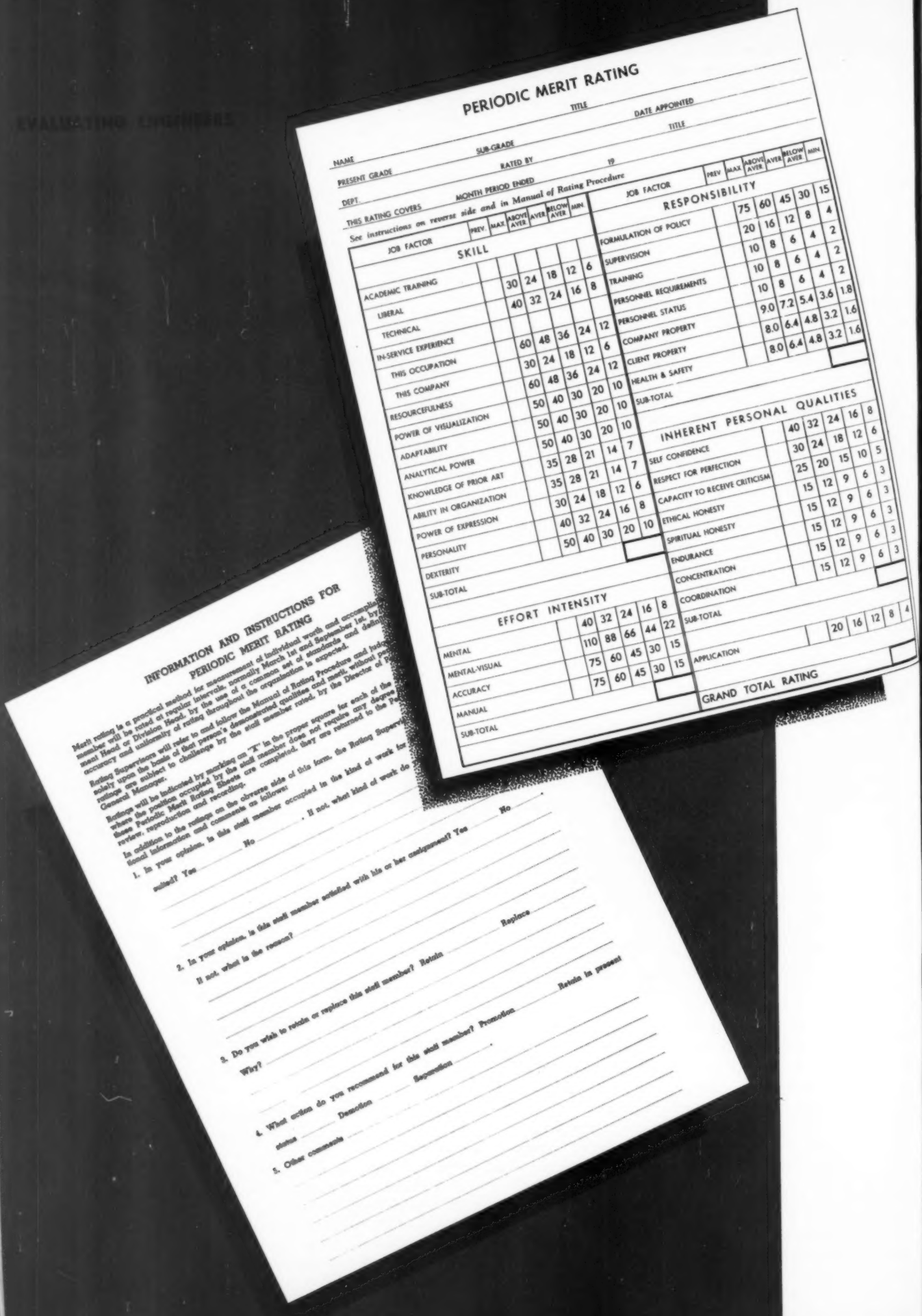
Putting together the selected job factors by rank with the maximum point values computed for each rank completes the overall scale which appears on the accompanying PERIODIC MERIT RATING CHART. These maxima are divided into five equal parts for the five degrees of each job factor which are used in rating the individual job. The chart indicates that these

Table 2—General Ranking of Factors

1.	Effort intensity	mental-visual
2.	Effort intensity	accuracy
	Responsibility	formulation of policy
		manual
3.	Skill	resourcefulness
	In-service experience	this occupation
4.	Skill	power of visualization
		adaptability
		analytical power
		dexterity
5.	Academic training	technical
	Skill	personality
	Effort intensity	mental
	Inherent personal qualities	self-confidence
6.	Skill	knowledge of prior art
		ability in organization
7.	Academic training	liberal
	In-service experience	this company
	Skill	power of expression
	Inherent personal qualities	respect for perfection
8.	Inherent personal qualities	capacity to receive criticism
9.	Responsibility	supervision application
10.	Inherent personal qualities	ethical honesty
		spiritual honesty
		endurance
		concentration
		co-ordination
11.	Responsibility	training
		personal requirements
		personal status
12.	Responsibility	company property
13.	Responsibility	client property
		health and safety

Table 3—Point Values for Factor Ranks

Rank	Point Value (assigned maximum)	Factors (no.)	Extension (total points)
1	110	1	110
2	75	3	225
3	60	2	120
4	50	4	200
5	40	4	160
6	35	2	70
7	30	4	120
8	25	1	25
9	20	2	40
10	15	5	75
11	10	3	30
12	9	1	9
13	8	2	16
Total		34	1200



PERIODIC MERIT RATING

NAME _____ TITLE _____ DATE APPOINTED _____

PRESENT GRADE _____ SUB-GRADE _____ TITLE _____

DEPT _____ RATED BY _____

THIS RATING COVERS _____ MONTH PERIOD ENDED _____ 19__

See instructions on reverse side and in Manual of Rating Procedure

JOB FACTOR	PREV.	MAX.	ABOVE AVER.	AVER.	BELOW AVER.	MIN.
SKILL						
ACADEMIC TRAINING		30	24	18	12	6
LIBERAL		40	32	24	16	8
TECHNICAL						
IN-SERVICE EXPERIENCE		60	48	36	24	12
THIS OCCUPATION		30	24	18	12	6
THIS COMPANY		60	48	36	24	12
RESOURCEFULNESS		50	40	30	20	10
POWER OF VISUALIZATION		50	40	30	20	10
ADAPTABILITY		50	40	30	20	10
ANALYTICAL POWER		35	28	21	14	7
KNOWLEDGE OF PRIOR ART		35	28	21	14	7
ABILITY IN ORGANIZATION		30	24	18	12	6
POWER OF EXPRESSION		40	32	24	16	8
PERSONALITY		50	40	30	20	10
DEXTERITY						
SUB-TOTAL						

JOB FACTOR	PREV.	MAX.	ABOVE AVER.	AVER.	BELOW AVER.	MIN.
RESPONSIBILITY						
FORMULATION OF POLICY		75	60	45	30	15
SUPERVISION		20	16	12	8	4
TRAINING		10	8	6	4	2
PERSONNEL REQUIREMENTS		10	8	6	4	2
PERSONNEL STATUS		10	8	6	4	2
COMPANY PROPERTY		9.0	7.2	5.4	3.6	1.8
CLIENT PROPERTY		8.0	6.4	4.8	3.2	1.6
HEALTH & SAFETY		8.0	6.4	4.8	3.2	1.6
SUB-TOTAL						
INHERENT PERSONAL QUALITIES						
SELF CONFIDENCE		40	32	24	16	8
RESPECT FOR PERFECTION		30	24	18	12	6
CAPACITY TO RECEIVE CRITICISM		25	20	15	10	5
ETHICAL HONESTY		15	12	9	6	3
SPIRITUAL HONESTY		15	12	9	6	3
ENDURANCE		15	12	9	6	3
CONCENTRATION		15	12	9	6	3
COORDINATION		15	12	9	6	3
SUB-TOTAL						
EFFORT INTENSITY						
MENTAL		40	32	24	16	8
MENTAL-VISUAL		110	88	66	44	22
ACCURACY		75	60	45	30	15
MANUAL		75	60	45	30	15
SUB-TOTAL						
APPLICATION		20	16	12	8	4
GRAND TOTAL RATING						

INFORMATION AND INSTRUCTIONS FOR PERIODIC MERIT RATING

Merit rating is a practical method for measurement of individual worth and accomplis
member will be rated at regular intervals, normally March 1st and September 1st, by
ment Head or Division Head, by the use of a common set of standards and defin
accuracy and uniformity of rating throughout the organization is expected.

Rating Supervisors will refer to and follow the Manual of Rating Procedure and judg
solely upon the basis of that person's demonstrated qualities and merit, without pre
ratings are subject to challenge by the staff member rated, by the Director of P
General Manager.

Ratings will be indicated by marking an "X" in the proper square for each of the
where the position occupied by the staff member does not require any degree
these Periodic Merit Rating Sheets are completed, they are returned to the Pe
review, reproduction and recording.

In addition to the ratings on the obverse side of this form, the Rating Supervi
final information and comments as follows:

1. In your opinion, is this staff member occupied in the kind of work for
suited? Yes _____ No _____ . If not, what kind of work do

2. In your opinion, is this staff member satisfied with his or her assignment? Yes _____ No _____ .
If not, what is the reason?

3. Do you wish to retain or replace this staff member? Retain _____ Replace _____
Why? _____

4. What action do you recommend for this staff member? Promotion _____ Retain in present status _____ Demotion _____ Separation _____

5. Other comments _____



Photo, courtesy General Electric Co.

". . . creative engineering is now recognized to require a degree of salesmanship for the reason that acceptance of the engineer's product rests, in large measure, upon the layman's faith in the engineer . . ."

values are used also for periodic merit rating of job incumbents, a process which will be described later in this article.

Evaluation of Individual Jobs: The interviews with staff members established certain reference points which were useful in evaluating the individual jobs, in each of the eleven departments of the enterprise. These reference points were the job which demanded:

1. The maximum of each job factor
2. More than the average demand of each job factor
3. The average of each job factor
4. Less than the average demand of each job factor
5. The minimum of each job factor
6. None of each job factor.

As might be expected, most of the 78 jobs in the organization appear as the 'reference-point' for one of the six demand levels in one or more job factors. At the extremes of maximum and zero demand, a few jobs are reference points for several factors. Inevitably, the top jobs in creative engineering such as project manager, project engineer and director of industrial design demand the maxima in the job factors which pertain to creative work, while the routine, nontechnical jobs such as janitor-watchman and blueprint operator demand the minima or none of most job factors. Average demand for each job factor is found in all of the eleven departments including the administrative departments.

Each reference-point job and the degree of demand in that job for each job factor, is a point of departure from which the demand in two or more other jobs is defined by comparison. To illustrate, the project manager's job demands the maximum of resourcefulness in terms of degree, frequency and variety. All other jobs which demand the same degree, frequency and variety are rated at the same level for resourcefulness as the project manager. The process of evaluating all jobs involves comparison between each job

SUMMARY OF JOB VALUES

(ALL JOBS)

DEPT.	JOB TITLE	SKILL														EF
		ACADEMIC TRAINING		IN-SERVICE EXPERIENCE		RESOURCEFULNESS	POWER OF VISUALIZATION	ADAPTABILITY	ANALYTICAL POWER	KNOWLEDGE OF PRIOR ART	ABILITY IN ORGANIZATION	POWER OF EXPRESSION	PERSONALITY	DEXTERITY	SUB-TOTAL	MENTAL
		Liberal	Technical	This Occupation	This Company											
PRODUCT DEVELOPMENT	Project Manager	30	40	60	30	60	40	50	50	21	35	30	40	--	406	40
	Project Engineer	18	24	48	12	36	40	30	40	28	21	18	24	--	341	24
	Project Designer	18	24	48	12	36	30	30	40	21	14	12	16	--	301	16
	Project Assistant - Senior	12	24	36	6	24	20	30	30	21	14	6	16	--	237	16
	Project Assistant - Junior	12	16	24	--	12	10	30	20	14	--	--	--	--	138	24
	Analyst	18	24	24	--	24	20	10	40	28	--	--	--	--	188	24
MACHINE DEVELOPMENT	Director	18	32	48	24	48	50	30	50	28	21	18	24	10	401	32
	Designer	18	24	36	12	36	40	30	40	21	14	12	8	10	301	24
ENGINEERING DESIGN	Chief Designer	18	32	48	18	48	50	40	40	28	28	18	24	--	392	24
	Chief Draftsman	18	24	48	18	12	10	20	10	28	28	18	32	--	266	24
	Supervising Designer	18	24	48	18	36	30	30	30	21	21	12	16	--	304	16
	Checker	12	24	48	24	12	30	10	30	28	7	12	8	--	245	8
	Senior Designer	12	24	36	12	36	20	30	20	21	7	6	16	--	242	8
	Junior Designer	6	16	24	6	24	10	30	20	14	--	--	--	--	150	24
	Senior Draftsman	6	8	24	6	12	20	20	10	14	7	--	--	--	127	16
	Junior Draftsman	6	8	24	6	12	--	20	--	14	--	--	--	--	90	8
	Detailer - Tracer	6	--	12	--	--	--	10	--	7	--	--	--	--	35	8
	Blueprint Supervisor	--	--	--	--	--	--	--	--	14	7	--	--	--	21	16
	Blueprint Operator	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8
INDUSTRIAL DESIGN	Director	30	40	60	30	60	50	50	30	28	21	18	24	30	471	32
	Supervising Designer	18	24	48	18	48	40	30	30	21	21	18	24	20	360	32
	Supervising Architect	18	24	48	12	36	40	20	20	28	21	18	24	20	329	32
	Principal Designer	18	24	48	12	36	30	30	10	21	14	12	16	10	391	24
	Principal Architect	18	24	48	6	24	30	20	20	28	14	12	16	10	270	24
	Senior Designer	12	24	36	12	36	20	30	20	21	7	6	16	10	250	8
	Senior Architect	12	24	36	6	24	20	20	20	28	7	6	16	10	229	8
	Senior Design Technician	6	24	48	6	48	20	20	10	28	--	--	8	40	258	--
	Junior Design Technician	6	24	36	6	36	20	20	10	21	--	--	8	30	217	--
	Junior Designer	6	16	12	--	24	10	20	10	14	--	--	8	10	130	16
	Design Apprentice	6	8	--	--	12	--	20	10	7	--	--	8	10	81	16
INDUSTRIAL ENGINEERING	Director	30	40	60	30	60	50	50	50	35	35	18	24	--	482	40
	Chief Industrial Engineer	18	24	48	12	36	30	20	40	21	21	18	24	--	312	24
	Industrial Engineer	18	24	48	12	36	30	20	30	21	14	18	24	--	295	24
	Production Consultant	6	16	48	6	48	20	20	10	21	7	12	8	--	222	16
	Senior Technician	6	16	36	6	36	20	20	10	21	--	--	8	20	199	16
	Processor	6	16	24	--	24	20	20	10	14	--	--	--	--	134	8
	Technician	6	8	12	--	12	--	10	10	7	--	--	--	10	75	8
	Junior Technician	6	--	12	--	--	--	10	--	7	--	--	--	10	45	8
	Technician Apprentice	--	--	--	--	--	--	10	--	7	--	--	--	10	27	--
ELECTRONIC DEVELOPMENT	Director	18	32	48	18	60	40	40	30	35	28	18	24	20	411	24
	Chief Electronic Designer	18	32	48	12	48	20	10	20	28	14	6	8	20	284	16
	Senior Electronic Designer	12	16	36	6	36	20	10	20	21	7	6	8	20	198	16
	Senior Electronic Technician	6	16	24	--	12	10	10	10	14	7	--	--	30	139	8
	Junior Electronic Designer	6	16	24	--	12	10	--	--	7	--	--	--	--	75	8
	Junior Electronic Technician	--	8	12	--	12	--	--	--	7	--	--	--	10	49	8
TOOL DESIGN	Chief Tool Designer	18	32	48	18	48	50	30	40	35	21	18	16	20	394	24
	Supervising Tool Designer	12	24	48	12	48	50	20	30	28	14	12	8	10	316	24
	Principal Tool Designer	12	24	36	6	48	40	20	30	28	7	6	8	10	275	24
	Senior Tool Designer	6	24	36	6	36	30	20	20	21	7	6	8	--	220	16
	Senior Tool Technician	--	16	36	6	12	20	10	10	28	--	--	--	40	178	8
	Junior Tool Designer	6	16	24	--	12	10	10	10	21	--	--	--	10	119	8
	Junior Tool Technician	--	16	12	--	12	--	--	--	14	--	--	--	10	64	8
	Tool Detailer	--	8	12	--	--	--	--	--	7	--	--	--	10	37	8
	Tool Design Apprentice	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8
EXPERIMENTAL MANUFACTURING	Superintendent	12	24	48	12	48	50	20	10	28	21	6	8	10	297	8
	Senior Machine & Tool Builder	--	16	48	--	36	40	20	10	21	7	6	--	50	254	8
	Machine & Tool Builder	--	8	36	--	36	40	20	10	21	7	--	--	40	218	--
	Junior Machine & Tool Builder	--	8	24	--	36	30	20	--	21	--	--	--	30	169	--
	Senior Machinist	--	--	24	--	24	20	10	--	14	--	--	--	30	122	--
	Machinist	--	--	12	--	24	10	10	--	7	--	--	--	20	83	--
	Junior Machinist	--	--	--	--	12	10	--	--	--	--	--	--	10	32	--
	Machinist Apprentice	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NEW PRODUCTS	Director	18	32	60	6	36	50	40	40	35	21	24	16	--	378	32
ADMINISTRATION	Office Manager	18	16	36	6	12	10	10	--	28	21	24	32	--	213	24
	Executive Secretary	18	8	24	--	12	--	--	--	21	7	18	24	--	132	24
	Accountant	12	16	36	--	12	--	--	10	21	--	--	--	--	107	24
	Paymaster	6	8	12	--	--	--	--	--	7	--	--	16	--	49	--
	Senior Accounting Clerk	6	8	24	--	--	--	--	--	7	--	--	--	--	45	16
	Secretary	6	--	12	--	12	--	--	--	14	--	12	16	--	72	8
	Junior Accounting Clerk	6	--	12	--	--	--	--	--	--	--	--	--	--	18	16
	Librarian	6	--	12	--	12	10	--	--	21	--	--	--	--	61	8
	Stenographer	6	--	12	--	--	--	--	--	7	--	6	8	10	49	16
	Switchboard Operator	--	--	12	--	12	10	--	--	7	--	24	8	20	93	8
PERSONNEL, PURCHASING AND MAINTENANCE	Director	18	8	48	12	36	30	30	20	28	14	18	24	--	286	24
	Maintenance Foreman	--	--	36	--	36	40	10	--	28	7	--	--	50	207	--
	General Maintenance Mechanic	--	--	24	--	24	30	--	--	21	--	--	--	50	149	--
	Receiving & Shipping Clerk	--	--	--	--	--	--	--	--	--	--	--	--	40	40	8
	Maintenance Mechanic	--	--	12	--	12	10	--	--	14	--	--	--	50	98	--
	Janitor - Watchman	--	--	--	--	12	--	--	--	--	--	--	--	30	42	--
	Charwoman	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

	EFFORT INTENSITY					RESPONSIBILITY									INHERENT PERSONAL QUALITIES									APPLICATION	GRAND TOTAL
	MENTAL	MENTAL-VISUAL	ACCURACY	MANUAL	SUB-TOTAL	FORMULATION OF POLICY	SUPERVISION	TRAINING	PERSONNEL REQUIREMENTS	PERSONNEL STATUS	COMPANY PROPERTY	CLIENT PROPERTY	HEALTH & SAFETY	SUB-TOTAL	SELF-CONFIDENCE	RESPECT FOR PERFECTION	CAPACITY TO RECEIVE CRITICISM	ETHICAL HONESTY	SPIRITUAL HONESTY	ENDURANCE	CONCENTRATION	COORDINATION	SUB-TOTAL		
	40	110	60	--	210	75	20	8	10	10	9.0	6.4	8.0	146.4	40	30	25	9	15	9	9	6	138	20	1000.4
	24	88	45	--	157	30	12	6	4	4	3.6	4.8	1.6	66.0	24	24	15	15	9	12	12	3	114	16	694.0
	16	66	45	--	127	--	--	4	--	--	1.8	1.6	--	7.4	16	12	20	12	9	6	9	3	87	20	542.4
	16	44	45	--	105	--	--	2	--	--	--	--	--	2.0	8	18	15	15	9	6	6	3	80	20	444.0
	24	66	60	--	150	--	--	--	--	--	--	--	--	--	--	--	20	15	6	9	3	--	53	20	361.0
	24	22	45	--	91	--	--	--	--	--	1.8	1.6	--	3.4	16	18	15	12	6	3	12	--	82	12	376.4
	32	88	45	--	165	30	16	8	8	8	3.6	6.4	4.8	84.8	32	24	15	12	9	12	12	9	125	12	797.8
	24	66	45	--	135	--	12	4	--	--	3.6	4.8	4.8	29.4	24	24	20	12	9	12	12	9	122	16	603.4
	24	88	60	--	172	15	16	8	8	6	7.2	6.4	1.6	68.2	32	30	15	15	9	12	12	6	131	16	779.2
	24	88	60	--	172	45	20	10	10	10	9.0	3.2	1.6	108.8	32	24	10	15	9	6	12	3	111	12	669.8
	16	66	45	--	127	--	--	4	--	--	1.8	1.6	--	7.4	16	12	20	12	9	6	9	3	87	20	545.4
	8	110	75	--	193	--	--	--	--	--	--	--	--	--	24	30	5	15	6	6	15	3	104	12	554.0
	8	44	45	--	97	--	--	--	--	--	--	--	--	--	8	18	15	15	9	6	6	3	100	16	449.0
	24	66	60	--	150	--	--	--	--	--	--	--	--	--	--	--	20	15	6	9	3	--	53	16	369.0
	16	44	30	--	90	--	--	--	--	--	--	--	--	--	--	24	15	9	6	6	9	3	72	20	309.0
	8	22	30	--	60	--	--	--	--	--	--	--	--	--	--	24	20	9	6	12	12	3	86	20	256.0
	8	--	45	--	53	--	--	--	--	--	--	--	--	--	--	30	25	9	6	15	15	3	103	20	211.0
	16	--	--	15	31	--	4	4	2	--	3.6	--	4.8	18.4	8	6	10	6	6	12	12	12	72	20	142.4
	8	--	--	15	23	--	--	--	--	--	--	--	--	--	--	--	15	--	3	15	15	9	57	20	100.0
	32	110	45	--	187	75	16	10	10	10	9.0	4.8	4.8	139.6	40	30	25	15	9	12	15	12	158	20	975.6
	32	66	45	--	143	15	12	8	6	2	3.6	1.6	1.6	49.8	32	24	20	12	6	9	12	6	121	12	685.8
	32	88	60	--	180	15	12	8	6	2	3.6	1.6	1.6	49.8	32	18	15	9	6	9	12	6	107	12	677.8
	24	66	45	--	135	--	8	8	--	--	1.8	1.6	--	19.4	32	24	10	12	6	9	6	9	108	12	565.4
	24	66	30	--	120	--	8	8	--	--	1.8	1.6	--	19.4	32	24	10	12	9	9	6	9	111	12	532.4
	8	44	45	--	97	--	--	--	--	--	--	--	--	--	8	18	15	15	6	6	6	3	77	20	444.0
	8	44	45	--	97	--	--	--	--	--	--	--	--	--	8	18	15	15	6	6	6	3	77	20	423.0
	--	22	45	15	82	--	16	8	4	2	5.4	--	4.8	40.2	8	30	10	15	6	12	9	15	105	12	497.2
	--	44	30	15	89	--	--	--	--	--	--	--	--	--	8	18	15	9	6	3	6	9	74	8	388.0
	16	66	15	--	97	--	--	--	--	--	--	--	--	--	8	12	20	9	6	9	6	6	76	16	319.0
	16	66	15	--	97	--	--	--	--	--	--	--	--	--	--	12	25	9	6	12	12	--	76	20	274.0
	40	110	60	--	210	75	16	8	10	10	3.6	3.2	1.6	127.4	40	30	25	12	9	12	12	--	140	20	979.4
	24	66	45	--	135	45	16	8	6	6	3.6	1.6	--	86.2	32	18	20	12	6	15	15	9	127	16	676.2
	24	66	45	--	135	--	8	4	--	--	5.4	3.2	--	20.6	32	18	15	12	6	12	9	--	104	12	566.6
	16	44	45	--	105	--	--	--	--	--	--	--	--	--	8	30	10	12	6	12	9	--	87	20	444.0
	16	66	30	--	112	--	--	--	--	--	--	--	--	--	8	12	10	15	6	9	6	9	75	8	394.0
	8	66	15	--	89	--	--	--	--	--	--	--	--	--	8	12	20	9	6	9	6	6	76	16	315.0
	8	44	15	30	97	--	--	--	--	--	--	--	--	--	8	12	15	9	3	6	3	9	65	20	257.0
	8	22	30	30	90	--	--	--	--	--	--	--	--	--	--	6	20	9	3	6	3	6	59	20	214.0
	--	22	30	30	82	--	--	--	--	--	--	--	--	--	--	6	25	9	3	9	6	-	58	20	187.0
	24	66	45	--	135	30	16	10	10	10	7.2	6.4	1.6	91.2	32	30	15	12	9	12	15	9	134	16	787.2
	16	66	45	--	127	--	8	8	4	2	5.4	1.6	--	29.0	32	18	15	12	9	9	9	9	113	12	565.0
	16	66	45	--	127	--	8	6	2	2	5.4	1.6	--	25.0	24	18	15	12	9	9	9	9	105	12	467.0
	8	44	60	15	127	--	8	6	--	--	5.4	--	--	19.4	24	18	10	12	9	6	6	12	97	8	390.4
	8	66	60	--	134	--	--	--	--	--	--	--	--	--	24	18	25	15	9	12	15	9	127	20	356.0
	8	22	45	30	105	--	--	--	--	--	--	--	--	--	8	12	25	9	3	6	3	9	75	20	249.0
	24	110	45	--	179	15	12	8	6	6	3.6	--	3.2	53.8	32	30	15	12	6	15	15	--	125	20	771.8
	24	66	45	--	135	--	8	8	4	4	1.8	1.6	--	27.4	32	24	20	12	6	15	12	6	127	16	621.4
	24	44	45	--	113	--	4	6	--	--	1.8	1.6	--	13.4	32	24	15	12	6	15	6	6	116	20	537.4
	16	44	45	--	105	--	--	4	--	--	--	--	--	4.0	24	18	15	9	6	12	6	6	96	20	425.0
	8	22	30	15	75	--	8	6	--	--	3.6	--	--	17.6	24	30	10	12	6	6	9	12	109	8	387.6
	8	44	45	--	97	--	--	--	--	--	--	--	--	--	8	24	15	9	6	6	6	3	77	16	309.0
	8	22	45	30	105	--	--	--	--	--	--	--	--	--	8	12	20	9	3	6	3	6	67	20	256.0
	8	--	45	--	53	--	--	--	--	--	--	--	--	--	--	30	20	9	6	15	15	3	98	20	208.0
	8	44	30	--	82	--	--	--	--	--	--	--	--	--	--	18	20	3	6	15	15	3	80	20	182.0
	8	66	75	--	149	45	16	10	8	8	9.0	3.2	8.0	111.2	32	30	5	15	9	3	9	15	118	12	687.2
	8	44	45	15	112	--	--	--	--	--	--	--	--	--	24	24	10	6	9	--	6	15	94	12	472.0
	--	22	30	30	82	--	--	--	--	--	--	--	--	--	16	18	15	6	6	--	--	12	73	12	385.0
	--	--	30	45	75	--	--	--	--	--	--	--	--	--	8	18	20	3	6	--	--	9	64	12	320.0
	--	--	30	30	60	--	--	--	--	--	--	--	--	--	8	24	10	6	6	--	9	9	72	12	266.0
	--	--	30	30	60	--	--	--	--	--	--	--	--	--	--	18	15	6	6	--	6	9	60	16	219.0
	--	--	45	30	75	--	--	--	--	--	--	--	--	--	--	12	20	6	6	--	9	9	62	16	185.0
	--	--	45	30	75	--	--	--	--	--	--	--	--	--	--	6	25	6	6	--	12	9	64	20	159.0
	32	88	45	--	165	60	--	--	--	--	5.4	6.4	--	71.8	32	18	25	15	9	9	12	--	128	20	762.8
	24	22	30	--	76	30	16	8	--	8	7.2	--	--	84.2	32	18	15	6	12	9	9	--	101	12	486.2
	24	--	30	--	54	--	12	4	--	--	--	--	--	16.0	24	12	10	6	6	6	12	9	85	20	307.0
	24	--	45	--	69	--	--	--	--	--	--	--	--	--	24	24	--	12	3	6	9	--	78	12	266.0
	--	22	45	--	67	--	--	--	--	--	--	--	--	--	24	30	15	3	12	3	9	--	96	8	220.0
	16	--	30	--	46	--	--	--	--	--	--	--	--	--	16	24	--	12	3	9	12	--	76	12	179.0
	8	--	30	--	38	--	--	--	--	--	--	--	--	--	16	12	10	3	3	3	6	--	59	16	185.0
	16	--	45	--	61	--	--	--	--	--	--	--	--	--	16	18	10	12	3	6	12	--	77	20	176.0
	8	22	15	--	45	--	--	--	--	--	5.4	--	--	5.4	8	12	5	3	3	--	6	--	37	12	160.4
	16	--	30	--	46	--	--	--	--	--	--	--	--	--	8	12	10	3	3	3	6	--	45	16	156.0
	8	--	15	--	23	--	--	--	--	--	--	--	--	--	8	--	15	--	--	--	--	--	23	12	151.0
	24	66	30	--	120	60	16	6	6	6	9.0	8.0	8.0	119.0	32	18	20	9	12	6	6	--	103	12	640.0
	--	--	15	75	90	--	12	--	2	--	7.2	--	6.4	27.9	16	18	5	--	9	--	--	--	48	8	380.9
	--	--	30	75	105	--	--	--	--	--	--	--	--	--	8	18	10	--	9	--	--	--	45	16	315.0
	--	--	45	75	128	--	--	--	--	--	--	6.4	6.4	12.8	--	--	20	--	6	--	--	--	26	12	218.8
	--	--	--	75	75	--	--	--	--	--	--	--	--	--	--	12	15	--	6	--	--	--	33	20	226.0
	--	--	--	45	45	--	--	--	--	--	9.0	8.0	--	17.0	--	18	5	--	9	--	--	--	34	16	154.0
	--	--	--	75	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12	87.0



Photo, courtesy Allis-Chalmers Mfg. Co.

". . . mental-visual effort is required to create, in the literal sense, the clear mental concept not only of the end result . . . but also of the approach . . ."

and the reference-point jobs to determine which of the latter reflects the demand in the job in question and, therefore, the degree of that demand.

Once the degree of demand, in the six degrees selected, has been defined in a reference-point job, the evaluation of other individual jobs becomes a simple matter of objective judgement.

It is not enough to define the degree of job requirement for each factor merely as maximum, above-average, average, below-average, minimum, or none. Job requirements must be defined with reasonable accuracy and clarity so as to be understood easily by all members of the organization. The accompanying CLASSIFICATION LISTING OF JOB REQUIREMENTS defines by limited example the degree of requirement for each of the thirty-four job factors previously enumerated and cites the job which typifies each degree of requirement.

FINAL EVALUATION OF ALL JOBS: The chart, SUMMARY OF JOB VALUES, shows the final evaluations of all jobs, including the reference-point jobs and all other jobs related to them. Within each department, the jobs are arranged in the order of diminishing point value. Unfortunately, the scope of this article does not permit sufficient description of job duties to explain clearly the bases of applying point values in the many job factors. In another creative engineering organization, these duties will differ markedly as will the evaluations. To repeat an earlier statement, this chart has the primary value of indicating the vital distinctions between job factors and the need to recognize the relative values placed upon these distinctions.

ALLOCATION OF JOBS TO GRADES: The point values arrived at as shown in this chart contain many minute differences which are meaningless for the practical purposes of setting pay rates and promotional steps. Those minute differences were resolved by delineating job grades and by allocating each job to a grade on the basis of job point value. The chart, CONTENTS OF JOB GRADES, shows the system of grades adopted. It was decided that advancement of personnel should be made increasingly more difficult so that individuals approaching the top grades would possess obviously superior qualifications and that only the very best talents could win acceptance into the upper grades. It was also decided that the formula should be simple and understandable, and that a straight-line relationship should tie together the jobs in successive grades.

These decisions led to an increasing spread and content of grades wherein each grade had a greater spread of point value than the grade just below, with a straight-line curve of job values through all grades. The approximate geometric ratio of 1:2 was selected as reflecting the desirable rate of increase in content of job grades.

The job evaluation system herein described was designed to facilitate promotions and to assure that

CLASSIFICATION LISTING OF JOB REQUIREMENTS AND RELATED TYPICAL POSITIONS

Academic Training—Liberal

Maximum ..... *Project Manager*
Continual or frequent editing of technical reports covering extreme variety of projects and subjects, and frequent conferences with client-executives.

Above Average ..... *Project Engineer*
Frequent preparation of technical reports covering one project and normal variety of subjects, and occasional conferences with client-executives.

Average ..... *Project Designer*
Occasional preparation of parts of technical reports covering limited part of one project.

Below-Average ..... *Senior Designer*
Frequent conference on project development program including discussion of design approach and preparation of notes covering limited variety of industrial art.

Minimum....*Sr. Technician, Jr. Draftsman*
Intermittent discussion of project development program covering limited variety and degree of industrial art.

Academic Training—Technical

Maximum ..... *Dir. of Industrial Design*
Continual employment of advanced art as learned by specialized technical training covering extreme variety of art.

Above-Average.....*Dir. of Electronic Dev.*
Continual employment of advanced art in limited variety.

Average ..... *Supervising Tool Designer*
Occasional employment of normal variety and degree of art.

Below-Average.....*Sr. Machine Builder*
Occasional or intermittent employment of limited variety and degree of art.

Minimum ..... *Senior Accounting Clerk*
Employment of routine art as learned with minimum specialized training.

In-Service Experience—This Occupation

Maximum ..... *Dir. of Industrial Eng.*
Not less than 15 years of successful practicing experience.

Above-Average...*Dir. of Personnel, Purch.*
Not less than 12 years of successful practicing experience.

Average ..... *Office Manager*
Not less than 9 years of successful practicing experience.

Below-Average ..... *Processor*
Not less than 6 years of successful practicing experience.

Minimum ..... *Sr. Accounting Clerk*
Not less than 3 years of successful practicing experience.

In-Service Experience—This Company

Maximum ..... *Project Manager*
Having not less than six years' experience with company policies.

Above-Average.....*Dir. of Machine Dev.*
Having not less than four years' experience with company policies.

Average ..... *Chief Designer*
Having not less than two years' experience with company policies.

Below-Average.....*Supt. of Exp. Mfg.*
Having not less than one years' experience with company policies.

Minimum.....*Jr. Ind. Design Technician*
Having limited but less than one years' experience with company policies.

5. Resourcefulness

Maximum ..... *Project Manager*
Required continually to find and adapt the means of accomplishment in the extreme degree and variety of industrial art and to aid others in developing resourcefulness.

Above-Average.....*Supv. Ind. Designer*
Required frequently or intermittently to find and adapt the means of accomplishment in the extreme degree of a single industrial art.

Average ..... *Chief Ind. Engineer*
Required occasionally or intermittently to find and adapt the means of accomplishment in the normal degree of a single industrial art.

Below-Average...*General Maint. Mechanic*
Required seldom or intermittently to find and adapt the means of accomplishment in a limited variety of a single industrial art.

Minimum ..... *Janitor-Watchman*
Required seldom to find and adapt the means of accomplishment within a limited degree of method or art.

6. Power of Visualization

Maximum ..... *Chief Tool Designer*
Continually and frequently required to visualize the end result desired, and the approach, in the extreme varieties and degrees of complicated creative art, and to aid others.

Above-Average .... *Machine Dev. Designer*
Continually and frequently required to visualize the end result and the approach, in the normal varieties and degrees of complicated creative art.

Average ..... *Principal Ind. Designer*
Occasionally or intermittently required to visualize the end result and the technical approach, in the normal varieties and degrees of a single industrial art.

Below-Average ..... *Senior Machinist*
Seldom or intermittently required to visualize an end result and the technical approach, in the normal varieties and degrees of a single industrial art.

Minimum.....*Jr. Engrg. Designer*
Infrequently required to visualize an end result and the technical approach, in a limited variety and degree of a single industrial art.

7. Adaptability

Maximum ..... *Project Manager*
Continually required to adapt to extreme variety of conditions relating to projects, clients, creative arts and company administration, and to aid others in developing adaptability.

Above-Average.....*Chief Engrg. Designer*
Continually required to adapt to considerable variety of conditions relating to projects and creative engineering art.

Average..... .....*Chief Tool Designer*
Frequently required to adapt to normal variety of conditions within one branch of creative engineering art.

Below-Average .....*Production Consultant*
Occasionally required to adapt to normal variety of conditions within one branch of creative engineering art.

Minimum.....*Sr. Electronic Technician*
Seldom required to adapt to limited variety and degree of conditions within one branch of creative engineering art.

8. Analytical Power

Maximum ..... *Dir. of Machine Dev.*
Required continually to engage in technical analysis of complex mechanisms and to review analyses of others, in two or more branches of industrial art, and to aid others in developing analytical power.

Above-Average ..... *Chief Tool Designer*
Required frequently to engage in technical analysis of moderately complex mechanisms, and to review analyses of others, in a single branch of industrial art.

Average ..... *Supv. Ind. Designer*
Required occasionally to engage in technical analysis, in a single branch of industrial art.

Below-Average.....*Sr. Engrg. Designer*
Required occasionally to engage in simple technical analysis, in a single branch of industrial art.

Minimum.....*Sr. Electronic Designer*
Required infrequently to engage in simple technical analysis, in a single branch of industrial art.

9. Knowledge of Prior Art

Maximum ..... *Dir. of Ind. Engineering*
Having full knowledge of prior art in several branches of creative engineering and capable of instructing subordinates in all art employed.

Above-Average.....*Supt. of Exp. Mfg.*
Having full knowledge of prior art in one branch of creative engineering and capa-

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ble of instructing subordinates within the range of that branch.

Average ..... *Accountant*
Having broad knowledge of prior art in one branch of administrative operations, or of creative engineering.

Below-Average....*Sr. Electronic Technician*
Having limited knowledge of prior art in one branch of administrative operations or of creative engineering, plus general knowledge of sources of information regarding prior art.

Minimum ..... *Detailer—Tracer*
Having limited knowledge of prior art and of sources of information regarding prior art in one branch of creative engineering or administrative operations.

10. Ability in Organization

Maximum ..... *Project Manager*
Able to organize project programs, departmental activities, personnel and performance schedules for two or more projects and/or departments and the works of self and others, and to instruct others in the ability.

Above-Average.....*Chief Engrg. Designer*
Able to organize two or more project programs, departmental acticities, personnel and performance schedules for two or more projects within one department, including the works of others.

Average ..... *Office Manager*
Able to organize the routine and repetitive activities and performance schedules of the personnel within one department.

Below-Average ..... *Project Designer*
Able to organize the activities of self and a few co-workers in the performance of a segment of one project or routine departmental activity.

Minimum ..... *Machine and Tool Builder*
Able to organize the activities of self in the performance of diverse tasks within one segment of one project or departmental activity.

11. Power of Expression

Maximum ..... *Project Manager*
Capable of expressing, with forcefulness and clarity, in writing or orally, any proposition effecting project technology or company administration, to clients, superiors and subordinates, of presenting convincing arguments, and of aiding others to improve power of expression.

Above-Average .... *Switchboard Operator*
Capable of expressing, with assurance and clarity, orally, facts and circumstances and of satisfying hearer's requirements.

Average ..... *Executive Secretary*
Able to compose and express another's thoughts and to transmit others' views and instructions.

Below-Average ..... *Checker*
Able to compose and express own thoughts and to obtain understanding of associates and subordinates.

Minimum ..... *Sr. Ind. Designer*
Able to compose and express own thoughts and problems and to obtain instructions.

12. Personality

Maximum ..... *Project Manager*
Continually and frequently required to inspire clients, associates and subordinates, to win confidence in projects and programs proposed, and to assist others in developing personality.

Above-Average ..... *Office Manager*
Continually and frequently required to inspire associates, subordinates and others and to obtain co-operation in proposed projects and programs.

Average ..... *Dir. of Ind. Design*
Frequently required to obtain co-operation of associates and subordinates in the execution of projects.

Below-Average ..... *Sr. Ind. Designer*
Occasionally required to inspire confidence and obtain co-operation of associates and subordinates in project execution.

Minimum ..... *Stenographer*
Required to get along with associates amicably.

13. Dexterity

Maximum...*Sr. Machine and Tool Builder*
Continually engaged in skilled, precise, rapid, and complex manual operations as in fabrication and adjustments of delicate mechanisms, and in aiding others in developing dexterity.

Above-Average.....*Sr. Design Technician*
Continually engaged in variety of precise and accurate manual operations of artistic nature as in free-hand painting, sketching and photo retouching.

Average ..... *Sr. Electronic Technician*
Frequently engaged in closely coordinated manual work requiring precise control, as in assembling compact and complex electronic apparatus.

Below-Average .... *Switchboard Operator*
Continually engaged in series of rapid repetitive motions of simple nature or occasionally engaged in closely coordinated manual work of complex nature.

Minimum ..... *Junior Machinist*
Normally engaged in simple hand operations within wide limits of manual tolerance.

14. Effort Intensity—Mental

Maximum ..... *Project Manager*
Continually engaged in study of extreme variety of new, unusual and complex matters and in the exercise of independent judgment with respect to studies of subordinates.

Above-Average.....*Dir. of Ind. Design*
Continually engaged in study of considerable variety of new, unusual and complex matters within the scope of a single creative art.

Average ..... *Office Manager*
Performance of a variety of routine tasks requiring some study in carrying out prescribed standards.

Below-Average ..... *Sr. Draftsman*
Performance of a limited variety of repetitive tasks requiring limited study in carrying out prescribed standards, with occasional recourse to technical assistance.

Minimum.....*Receiving & Shipping Clerk*
Interpretation and application of instructions in the carrying out of simple operations, with frequent recourse to technical assistance.

15. Effort Intensity—Mental Visual

Maximum ..... *Chief Tool Designer*
Continually engaged in creating new technical concept and practical means of solving extreme variety on new, unusual and complex problems, in reviewing concepts and solutions of others, and in instructing others.

Above-Average.....*Chief Engrg. Designer*
Continually engaged in creating new technical concept and practical means of solving moderate variety of new, unusual and complex problems, within the limits of a single creative art.

Average ..... *Sr. Electronic Designer*
Under general instructions, frequently engaged in creating new technical concept and practical means of solving some variety of new problems within the limits of a single art.

Below-Average....*Ind. Engrg. Technician*
Under instructions, occasionally engaged in creating new technical concept and practical means of solving limited variety of new problems within the limits of a single art.

Minimum ..... *Jr. Draftsman*
Under precise instructions, infrequently engaged in creating new technical concept and practical means of solving simple technical problems.

16. Effort Intensity—Accuracy

Maximum ..... *Checker*
Continually engaged in disclosing errors and in obtaining accuracy and sound judgment in the work of many others on an extreme variety of technical art.

Above-Average.....*Chief Engrg. Designer*
Continually engaged in preventing errors in the work of many others on a considerable variety of technical matters.

Average ..... *Chief Tool Designer*
Continually engaged in preventing errors in the work of others within a single technical art.

Below-Average.....*Machinist Apprentice*
Required to supplement lack of own skill by considerable care and attention to avoid errors.

Minimum ..... *Jr. Ind. Designer*
Required to supplement own moderate skill by some care and attention to avoid errors.

17. Effort Intensity—Manual

Maximum ..... *Maintenance Foreman*
Performance of work requiring sustained exertion, special strength or continued exertion in cramped positions.

Above-Average ..... *(no position)*
Performance of work requiring discontinuous heavy exertion or occasional work in cramped positions.

Average ..... *Janitor-Watchman*
Performance of work requiring continuous walking or standing and handling of tools of moderate weight or bulk.

Below-Average....*Ind. Engrg. Technician*
Performance of work requiring discontinous walking or standing and light physical exertion.

Minimum ..... *Blueprint Supervisor*
Performance of work requiring infrequent light exertion with relief when desired.

18. Responsibility—Formulation of Policy

Maximum ..... *Project Manager*
Continually engaged in formulating policy affecting all operations and in approving policy proposed or employed by others.

Above-Average..*Dir. of Personnel, Purch.*
Continually engaged in formulating policy affecting operations of two or more departments, and in developing and proposing policy for other departments.

Average.....*Supt. of Exp. Mfg.*
Independently engaged in formulating policy affecting one large department.

Below-Average....*Dir. of Electronic Dev.*
Independently engaged in formulating policy affecting one small department.

Minimum.....*Chief Engrg. Designer*
Responsible for reviewing and recommending limited policy affecting one department.

19. Responsibility—Supervision

Maximum ..... *Project Manager*
Having full responsibility for the performance of many subordinates on varied and complex technical and administrative activities.

Above-Average.....*Dir. of Machine Dev.*
Having responsibility for the performance of one department.

Average ..... *Project Engineer*
Having responsibility for the performance of personnel assigned to one project or branch of creative art.

Below-Average..*Chief Electronic Designer*
Having responsibility for the performance of personnel assigned to one part of a project or specialized task.

Minimum ..... *Principal Tool Designer*
Having responsibility for the guidance of one or a few assistants in the performance of a small segment of a project.

20. Responsibility—Training

Maximum ..... *Dir. of Ind. Design*
Having responsibility for developing and conducting technical, in-service training of many others in the complete range of creative art.

Above-Average ..... *Chief Tool Designer*
Having responsibility for technical, in-service training of several others in a part of a branch of major creative art, or in the whole of a minor art.

Average ..... *Sr. Electronic Designer*
Having responsibility for assisting in technical, in-service training programs as directed.

Below-Average ..... *Ind. Engineer*
Having responsibility to guide and counsel several associates regularly in the solution of major individual problems.

Minimum ..... *Sr. Project Assistant*
Having responsibility to assist a few associates as requested in the solution of minor individual problems.

21. Responsibility—Personnel Requirements

Maximum ..... *Project Manager*
Having chief responsibility for size of staff by positions, pay rates, and definition of duties.

Above-Average.....*Supt. of Exp. Mfg.*
Having independent responsibility, within one large department, for making practical recommendations regarding manning.

Average ..... *Chief Tool Designer*
Having independent responsibility, within one small department, for making practical recommendations regarding manning.

Below-Average..*Sr. Ind. Design Technician*
Having responsibility when directed, for making practical recommendations regarding manning for a part of a department or branch of creative art.

Minimum ..... *Maintenance Foreman*
Having responsibility when directed, for making practical recommendations regarding manning of routine, noncreative jobs.

22. Responsibility—Personnel Status

Maximum ..... *Project Manager*
Having chief responsibility for authorizing recruitment, placement, status change, separation and other personnel actions affecting large numbers of employees assigned to two or more projects or departments.

Above-Average ..... *Office Manager*
Having responsibility for recommending personnel actions affecting employees of one large department.

Average ..... *Chief Tool Designer*
Having responsibility for recommending personnel actions affecting employees of one small department; or assisting in preparing recommendations affecting employees of a large department.

Below-Average ..... *Project Engineer*
Having responsibility to advise with superiors on personnel actions affecting employees of a part of a department or branch of creative art.

Minimum ..... *Chief Electronic Designer*
Having responsibility to perform certain occasional and minor clerical duties associated with personnel actions.

23. Responsibility—Company Property

Maximum ..... *Dir. of Personnel, Purch.*
Having continual responsibility for custody, preservation and proper application of company funds, valuable personal property and confidential information of major importance, and supervision of others responsible for same.

Above-Average....*Dir. of Electronic Dev.*
Having continual responsibility for custody and proper use of valuable personal property and confidential information by self and several subordinates.

Average ..... *Librarian*
Having constant individual responsibility for custody and proper use of valuable personal property.

Below-Average.....*Supv. Ind. Designer*
Having individual responsibility for proper use when assigned, of personal property of moderate value.

Minimum.....*Product Dev. Analyst*
Having occasional or infrequent responsibility for proper use of personal property of limited value.

24. Responsibility—Client Property

Maximum.....*Dir. of Personnel, Purch.*
Having constant individual responsibility for the custody, handling and protection of the valuable personal property of several clients including models, samples, drawings, etc., by self and others.

Above-Average....*Dir. of Electronic Dev.*
Having frequent and extended individual responsibility for classified and confidential information regarding clients' projects, and for others individually responsible.

Average ..... *Project Engineer*
Having frequent and extended individual responsibility for classified and confidential information regarding clients' projects.

Below-Average ..... *Chief Draftsman*
Having individual responsibility for the preservation of the personal property of two or more clients, of moderate value such as drawings.

Minimum ..... *Supv. Ind. Designer*
Having occasional or infrequent responsibility for short periods for the personal property of limited value of a single client.

25. Responsibility—Health and Safety

Maximum ..... *Supt. of Exp. Mfg.*
Having constant individual responsibility, in an environment of considerable hazard, for taking suitable precautions and for enforcing safety rules, for the protection of employees, customers and the public.

Above-Average .... *Maintenance Foreman*
Having constant individual responsibility for the maintenance of installed equipment in safe operating condition, and for regular inspection of such equipment for preventive maintenance.

Average ..... *Machine Dev. Designer*
Having frequent and extended individual responsibility for own performance as a source of hazard to many others, as in operating a powered mechanism for test purposes.

Below-Average ..... *Chief Tool Designer*
Having infrequent responsibility, for short periods and in any environment of limited hazard, for the observance of necessary safety precautions.

Minimum ..... *Chief Draftsman*
Having responsibility only for reporting conditions of environment having possible harmful effect upon health.

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(Continued from preceding page)

26. Inherent Qualities—Self Confidence

Maximum ..... *Dir. of Ind. Engineering*
Frequently required to win complete confidence of clients, associates and subordinates in proposals for handling matters of major importance and for disposing of involved controversial matters.

Above-Average ..... *Office Manager*
Frequently required to win respect and co-operation of associates and subordinates in undertaking new or untried methods and in accepting decisions on controversial matters.

Average ..... *Sr. Electronic Designer*
Capable of carrying through an involved technical assignment without delay due to uncertainty or indecision.

Below-Average..... *Sr. Accounting Clerk*
Capable of carrying through an extraordinary assignment without delay due to uncertainty or indecision.

Minimum ..... *Jr. Tool Designer*
Capable of carrying through an ordinary routine assignment with minimum delay due to uncertainty or indecision.

27. Inherent Qualities—Respect for Perfection

Maximum ..... *Project Manager*
Having profound knowledge of technical and commercial perfection and capable of selecting optimum economic degree of perfection to be attained, and to appraise the perfection attained by others.

Above-Average ..... *Sr. Machine Builder*
Capable of recognizing and interpreting the degree of perfection defined by others and of achieving that perfection in complex creative art.

Average ..... *Sr. Engrg. Designer*
Capable of selecting, defining and achieving optimum economic perfection in own work in a limited scope of creative art.

Below-Average ..... *Jr. Tool Technician*
Having working knowledge of practical perfection, and capable of developing understanding of technical and economic perfection.

Minimum ..... *Blueprint Supervisor*
Having working knowledge of practical perfection.

28. Inherent Qualities—Capacity for Criticism

Maximum ..... *Dir. of New Products*
Being constantly or frequently exposed to criticism of clients, superiors and associates and, with a wholly objective attitude, always able to accept and profit by criticism.

Above-Average ..... *Project Designer*
Being frequently exposed to criticism of superiors and associates and, with an objective attitude, usually able to accept and profit by criticism.

Average ..... *Switchboard Operator*
Being occasionally exposed to minor criticism for short periods and, with an objective attitude, usually able to accept and profit by criticism.

Below-Average ..... *Sr. Machine Builder*
Being exposed infrequently to minor criticism and, with an objective attitude, able to accept and profit by criticism.

Minimum ..... *Librarian*
Being rarely criticised and, with an objective attitude, able to accept and profit by criticism.

29. Inherent Qualities—Ethical Honesty

Maximum ..... *Project Engineer*
Required to observe highest order of professional ethics in own work and to develop ethical honesty in associates and subordinates.

Above-Average ..... *Project Designer*
Required to observe highest order of professional ethics in own work.

Average ..... *Tool Detailer*
Required to observe professional ethics within partial area of application.

Below-Average ..... *Senior Machinist*
Required to observe professional ethics within limited area of application.

Minimum ..... *Tool Design Apprentice*
Required to observe professional ethics within negligible area of application.

30. Inherent Qualities—Spiritual Honesty

Maximum ..... *Project Manager*
Continually exposed to opportunities for great personal gain by methods beyond prospect of detection, and always resisting temptation.

Above-Average ..... *Office Manager*
Continually exposed to opportunities for substantial personal gain by methods difficult of detection, and always resisting temptation.

Average ..... *Dir. of Ind. Design*
Frequently exposed to opportunities for personal gain by methods difficult of detection, and always resisting temptation.

Below-Average ..... *Executive Secretary*
Occasionally exposed to opportunities for personal gain by methods susceptible of delayed detection, and always resisting temptation.

Minimum ..... *Jr. Tool Technician*
Infrequently exposed to opportunities for limited personal gain and always resisting temptation.

31. Inherent Qualities—Endurance

Maximum ..... *Principal Tool Designer*
Capable of sustained performance at high pitch over extended periods including supervision of others.

Above-Average ... *Machine Dev. Designer*
Capable of sustained performance at high pitch over limited periods, including supervision of others.

Average ..... *Principal Ind. Designer*
Capable of occasional sustained performance at abnormal pitch including supervision of others.

Below-Average .... *Production Consultant*
Capable of sustained performance at high pitch over extended periods.

Minimum ... *Jr. Machine & Tool Builder*
Capable of sustained performance at high pitch over limited periods.

32. Inherent Qualities—Concentration

Maximum ..... *Dir. of Ind. Design*
Capable of giving exclusive attention over extended periods in a highly distracting environment, including supervision of others.

Above-Average .... *Machinist Apprentice*
Capable of giving exclusive attention over limited periods in a highly distracting environment.

Average ..... *Sr. Design Technician*
Capable of giving exclusive attention over limited periods in a distracting environment.

Below-Average ..... *Stenographer*
Capable of giving exclusive attention over short periods in a distracting environment.

Minimum ..... *Jr. Electronic Technician*
Capable of giving exclusive attention over short periods in a slightly distracting environment.

33. Inherent Qualities—Co-ordination

Maximum .... *Sr. Ind. Design Technician*
Capable of achieving completely harmonious relation between mental perception and manual dexterity, over a wide range of industrial art, and of assessing co-ordinative talents of others; as in freehand painting of complex detail.

Above-Average .. *Sr. Electronic Technician*
Capable of achieving generally harmonious relation between mental perception and manual dexterity, within a single creative art, and of assessing co-ordinative talents of others; as in adjusting delicate electronic devices.

Average ..... *Machine & Tool Builder*
Capable of achieving generally harmonious relation between mental perception and manual dexterity, within a single creative art, as in fitting, assembling and testing a delicate mechanism.

Below-Average *Jr. Tool Technician*
Capable of achieving limited harmonious relation between mental perception and manual dexterity, within a branch of a single creative art, as in fitting and assembling a complex fixture.

Minimum ..... *Project Engineer*
Capable of translating minute physical sensations into mental perception as in measuring vibration effects by sense of touch.

34. Application

Maximum ..... *Project Manager*
Capable of constantly unrelenting application, without benefit of supervision, and of obtaining like application of others.

Above-Average.....*Chief Engrg. Designer*
Capable frequently and for extended periods of unrelenting application, without benefit of supervision, and of obtaining like application of others.

Average ..... *Accountant*
Capable constantly of unrelenting application, without benefit of supervision.

Below-Average .. *Sr. Electronic Technician*
Capable frequently and for extended periods of unrelenting application, without benefit of supervision.

Minimum ..... *(no position)*
Capable occasionally and for short periods of close application under immediate supervision.

promotions are made as a result of demonstrated merit. Often, the performance of the individual in one job is not reliable evidence of his performance in a higher grade. The individual's inherent qualities may be deficient and he may be incapable of correcting those deficiencies. Promotions are properly made when:

(1) The individual's deficiencies are disclosed, and
(2) the individual's deficiencies are corrected.

Entrance Subgrade: Promotion of the individual is from one grade to the next higher and through subgrades within the higher grade. The first subgrade is the "entrance" subgrade which the individual enters as the first promotional step and where he remains for a period up to nine months, on a probationary basis, whether the individual enters the grade from a lower grade or as a new recruit from without the company. During this period, the individual's abilities are observed and assessed and it is determined whether or not those deficiencies can be overcome by limited training.

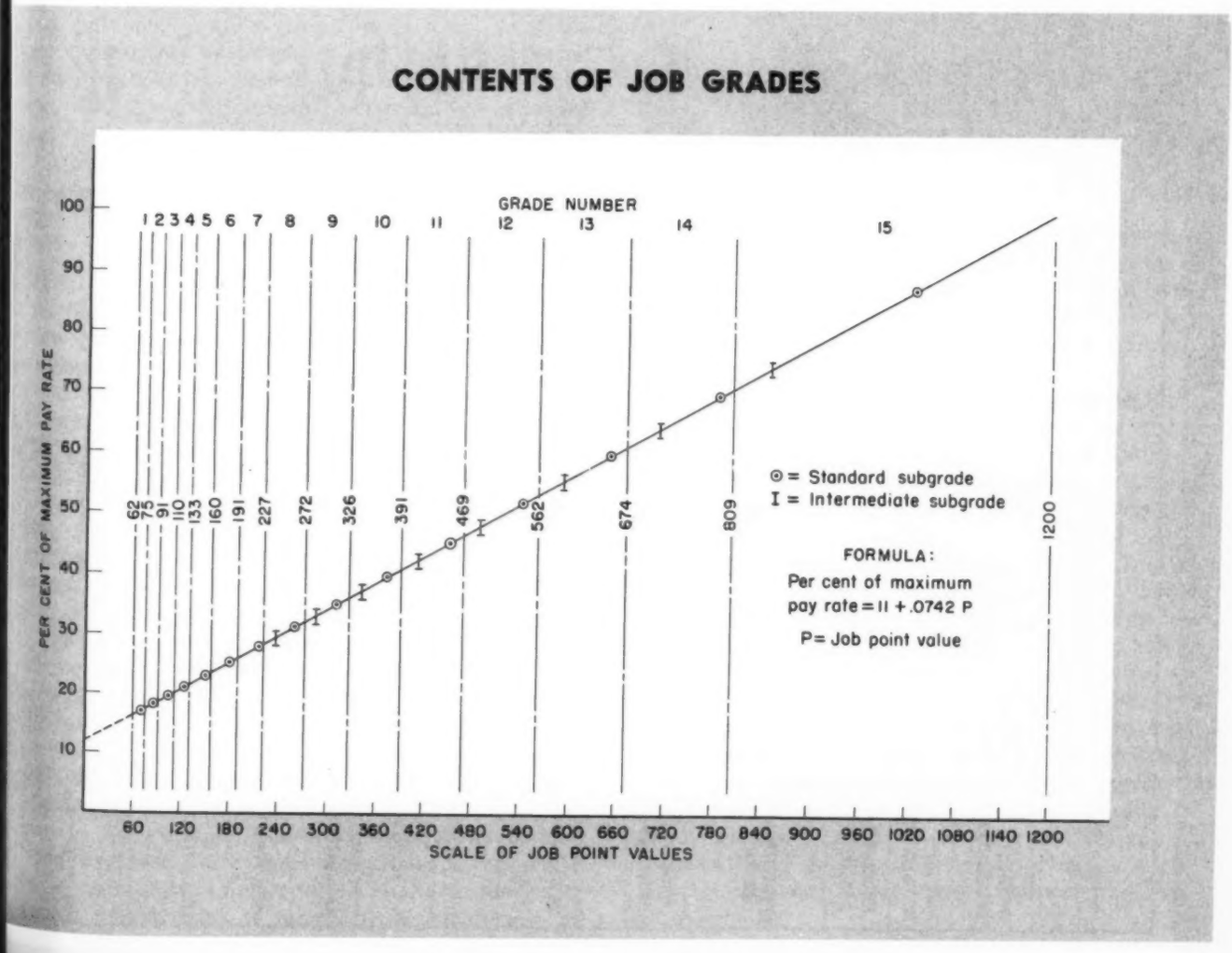
While occupying the entrance subgrade, the individual's status is probationary and he may be returned to the lower grade if he is deemed unqualified. The individual may be advanced from the entrance subgrade in less than nine months if he shows adequate promise, but in no event, in less than three months.

Intermediate Subgrade: Upon being advanced from the entrance subgrade, the individual enters the Intermediate subgrade with an increase in salary and may remain for any period up to fifteen months. While in this subgrade, the individual's deficiencies are corrected by in-service training and, at the conclusion of his stay in this subgrade, the individual is deemed to merit permanent status in the grade and position.

The individual's status while in the intermediate subgrade is still probationary. In the event that he does not respond to training and his deficiencies are not corrected by training within fifteen months, the individual may be restored to the lower grade. The individual may be advanced to the next higher subgrade at any time within fifteen months that demonstrated ability permits, but in not less than three months.

Standard Subgrade: The individual is promoted from intermediate subgrade to standard subgrade, at an increase in salary, where he remains for an indefinite period until he is ready for advancement to the next higher grade and an opening exists, or until he is promoted to the merit subgrade.

The individual has attained standard subgrade as a result, first, of having his deficiencies disclosed in the entrance subgrade and, second, of having those deficiencies corrected by training in the intermediate



ALLOCATION OF POSITIONS TO GRADES

DEPARTMENT	GRADE NUMBER 15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	NUMBER OF POINTS AT STANDARD 1,000	783	650	541	451	375	313	261	217	181	151	126	105	87	71
	PER CENT OF MAXIMUM PAY RATE AT STANDARD 85.2	69.0	59.3	51.5	44.7	39.0	34.2	30.5	27.5	24.5	22.5	20.5	19.0	17.5	16.5
PRODUCT DEVELOPMENT	*Project Manager*		*Project Engineer*	*Project Designer*	*Project Assistant Senior*	*Project Assistant Junior* *Analyst*									
MACHINE DEVELOPMENT		*Director*	*Designer*												
ENGINEERING DESIGN		*Chief Designer*	*Chief Draftsman*	*Supervising Designer Checker*	*Senior Designer*	*Junior Designer*	*Senior Draftsman*	*Junior Draftsman*	*Detailer Tracer*		*Blueprint Supervisor*		*Blueprint Operator*		
INDUSTRIAL DESIGN	*Director*		*Supervising Designer* *Supervising Architect*	*Principal Designer* *Principal Architect*	*Senior Designer* *Senior Architect* *Senior Design Technician*	*Junior Design Technician*	*Junior Designer*	*Design Apprentice*							
INDUSTRIAL ENGINEERING	*Director*		*Chief Industrial Engineer*	*Industrial Engineer*	*Production Consultant*	*Senior Technician*	*Processor*	*Technician*	*Junior Technician*	*Industrial Engineering Apprentice*					
ELECTRONIC DEVELOPMENT		*Director*		*Chief Electronic Designer*	*Senior Electronic Designer*	*Junior Electronic Designer* *Senior Electronic Technician*		*Junior Electronic Technician*							
TOOL DESIGN		*Chief Tool Designer*	*Supervising Tool Designer*	*Principal Tool Designer*	*Senior Tool Designer*	*Senior Tool Technician*	*Junior Tool Designer*	*Junior Tool Technician*	*Tool Detailer*	*Tool Design Apprentice*					
EXPERIMENTAL MANUFACTURING			*Super-intendent*		*Senior Machine & Tool Builder*	*Machine & Tool Builder*	*Junior Machine & Tool Builder*	*Senior Machinist*	*Machinist*	*Junior Machinist*	*Machinist Apprentice*				
NEW PRODUCTS		*Director*													
ADMINISTRATION					*Office Manager*		*Executive Secretary*	*Accountant*	*Paymaster* *Senior Accounting Clerk*	*Secretary* *Junior Accounting Clerk*	*Switchboard Operator* *Librarian* *Stenographer*				
MAINTENANCE			*Director*			*Maintenance Foreman*	*General Maintenance Mechanic*		*Maintenance Mechanic* *Receiving & Shipping Clerk*		*Janitor Watchman*			*Charwoman*	

subgrade. Thus, there should be little or no uncertainty that the individual is a permanent incumbent of the grade and position by the time he enters the standard subgrade. He should have become known to and accepted by his associates and he should have confirmed his determination to fulfill the demands of his position. There should be no occasion to question his qualifications until merit rating shows a reduction in those qualifications.

Merit Subgrade: While occupying standard subgrade, an individual may perform consistently with outstanding brilliance, and merit special recognition of that performance, while no vacancy exists in a higher grade to which the individual may be promoted. Such recognition is made possible by advancing the individual from standard subgrade to merit subgrade within the same grade, with increase in salary rate. The job point value and salary rate in the merit subgrade are the same, respectively, as the job point value and salary rate of the entrance subgrade of the next higher grade. Thus the "merit" employee receives recognition equal in his subgrade to that which would be given by promotion to the next higher grade.

The integrity of the merit subgrade must be protected by close limitation of the numbers of employees admitted to it. Normally, if the evaluation formula and the merit rating are sound, not more than ten per cent of the employees of the organization will be eligible for the merit subgrade and the ratio will be nearer five per cent in actual practice.

An individual may be promoted to merit subgrade after outstanding performance continued for a period of not less than six months or the interval of merit rating, and his dwell in merit subgrade is contingent upon continued outstanding performance as shown by merit rating at regular intervals. An individual may be demoted to standard subgrade when merit rating shows that his performance has deterioriated from outstanding to standard.

Point Values and Jobs in Grades: The point value demarcations between grades and subgrades, on the geometric progression system, are indicated in TABLE 4. The chart, ALLOCATION OF POSITIONS TO GRADES, shows how the 78 jobs fall into grades according to their total point values and the geometric system of fixing grade point values. This chart shows the promotional sequence of jobs and the relationships of jobs in separate parallel channels within the same department. For example, in the industrial design department, there are two parallel channels of which one is the design group which performs the basic creative work and the technician group which executes the designs by sketches, drawings, paintings, photographs and models. Likewise, there are parallel channels in the administration and maintenance departments. With two or more channels in the same department, two or more different jobs may have approximately equivalent point values and fall in the same grade.

Gaps appear between jobs in the same promotional chain as, for example, between project manager and project engineer. Such gaps are desirable to allow the insertion of added supervision as the organization expands by increase in numbers of employees in lower grades. This added supervision would include assistant project managers and assistant department directors.

PAY RATES: One of the principal uses of job evaluation is in computing pay rates and to set up pay rates which reflect, with reasonable accuracy, the relative requirements of jobs. Alone, a job evaluation formula cannot set or revise pay rates. Rates must conform to going rates for the industry and for the region, and they cannot exceed the company's capacity to pay. Where going rates for the industry and region must govern, job point values may be used to compare jobs with jobs in other enterprises so as to set up equivalent pay rates where the point values are equivalent.

Table 4—Point Value Demarcations Between Grades

Grade Number	Point Value of Subgrades				Points Spread
	Merit	Standard	Intermediate	Entrance	
1	75	71	66	62	13
2	91	87	80	75	16
3	110	105	97	91	19
4	135	126	116	110	23
5	160	151	140	133	27
6	191	181	168	160	31
7	227	217	201	191	36
8	272	261	239	227	45
9	326	313	285	272	54
10	391	375	343	326	65
11	469	451	412	391	78
12	562	541	494	469	93
13	674	650	592	562	112
14	809	783	710	674	135
15	1200	1000	852	809	391

Going salary scales in the industry and region may not be the governing influence in creative engineering, at least in all jobs in a promotional chain. This is particularly true since few creative engineering organizations have point values on which jobs can be compared.

In the engineering group where this job evaluation formula was applied, it was decided that company management would fix the maximum pay rate for the merit subgrade in the highest grade and that pay rates in all other grades and subgrades would be related equitably to that maximum rate. It was also agreed that the maximum rate might be changed from time-to-time to follow cost-of-living indices and that easy means were needed for recomputing all pay rates so as to keep all jobs in the same pay-relationship with each other. This was accomplished by identifying the maximum pay rate as 100 per cent and by applying a permanent lesser percentage to all other jobs.



Photo, courtesy Westinghouse Electric Corp.

"... training in creative engineering ... may be formalized by conferences, written tests, reports, and other means ..."

The straight-line curve of the chart, CONTENTS OF JOB GRADES, shows the correlation between job point values and per cent of maximum pay rate and the percentages for standard subgrades also appear at the top of the chart, ALLOCATION OF POSITIONS TO GRADES. The formula for this curve is $R = C + 0.0742\ P$ where R is per cent of maximum pay rate, C is a constant of 11 per cent, and P is the point value of any job or subgrade.

The constant C of 11 per cent appears for the reason that there can be no zero per cent of maximum pay rate and the actual pay rate for the lowest job cannot be less than the minimum pay rate specified by Federal or other statute. If the lowest job had an entrance point value of zero points, the 11 per cent minimum would require the legal minimum pay rate of 75c per hour or $1500 per year and the maximum pay rate would be $13,636 per year. The minimum point value herein used is 62 points and the pay rate is 15.6 per cent of maximum. If the legal minimum of $1500 per year is applied at this point, the maximum pay rate can be no more than $9600 per year. It appears that the formula provides ample flexibility between permissible limits.

Unfortunately, many companies cling to the traditional view that pay rates of salaried personnel should be kept secret. They refuse to accept the obvious truth that pay rates cannot be kept secret very long, and that the effort to maintain secrecy breeds disrespect among the salaried personnel. It is far better to publish pay rates for all to know, as well as the grades in which jobs are allocated and to allow the pay rates of individuals in grades to be known to all.

ALTERATION OF JOB POINT VALUES: No administrative practice can endure forever without change, and this is true of job evaluation. Although changes should be expected only infrequently, job requirements may change in some factors and these factors allow jobs to be re-evaluated realistically in relation to changes in skill, effort intensity, responsibilities and inherent personal qualities. In the re-evaluation of one job, one or more factors may require drastic change in degree, others small change, and still others no change. Individual new jobs may be added, or whole new departments, and the new jobs can be harmonized with existing jobs without disturbing the relationships of jobs. The point is that

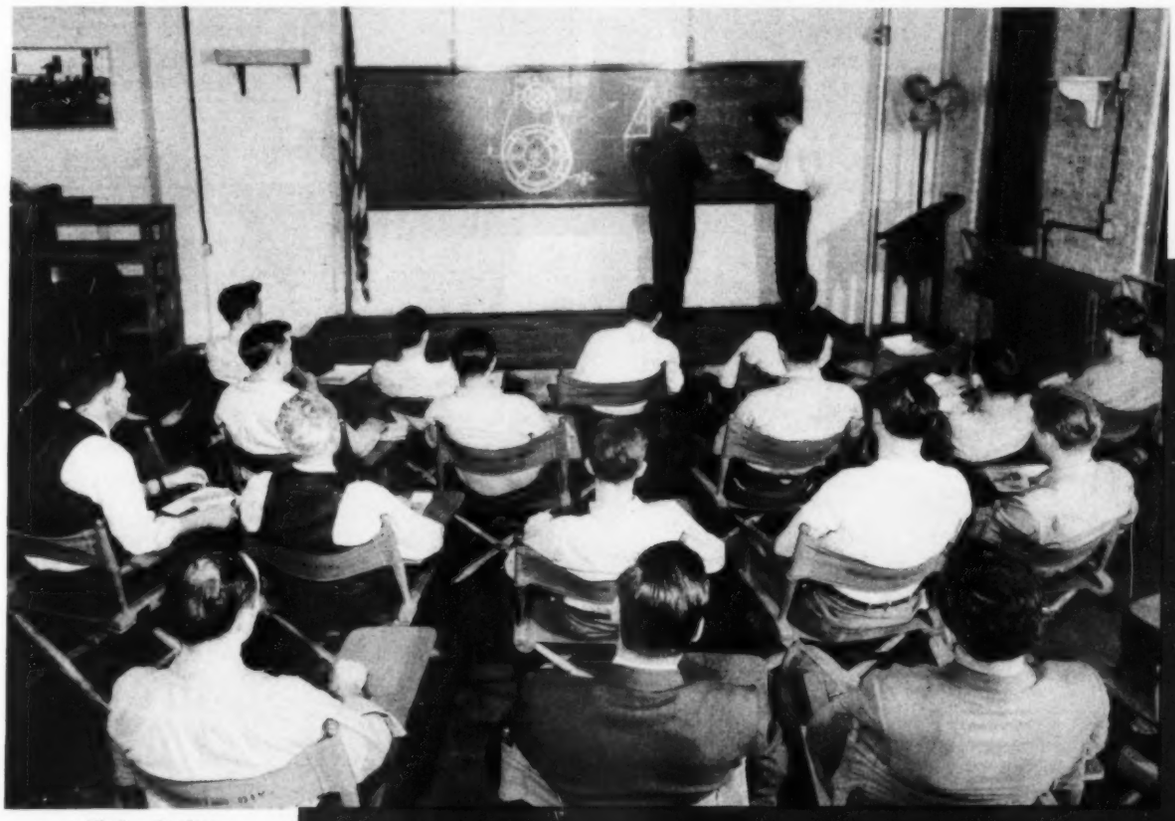
the job structure can be modified as necessary, in terms of clearly-defined job factors, without controversy and with least effort by using a job evaluation formula.

Assessing Creative Performance

Merit Rating: Like job evaluation, merit rating is not uncommon in commercial and industrial enterprises. Merit rating, in one form or another, probably is more common in creative engineering than job evaluation, for the good reason that engineers naturally are inclined to the objective view even in defining the merits of their organizations. Merit rating of engineers is more realistic when performed by engineers than when performed by personnel administrators. One school of thought holds that merit rating need not and cannot bear a close relationship to job evaluation. The reason given for this view is that job evaluation considers the job and the qualifications which it demands for successful performance, whereas merit rating considers the personality. When conducted with this view in mind, merit rating discloses quantitatively how well the individual has performed and behaved. It does not, however, disclose how well the individual has satisfied the stated requirements of the job nor whether the individual has demonstrated the capacity to satisfy the stated requirements of the higher job to which he might be promoted. Qualitatively, the rating is incomplete and of limited usefulness.

The other school of thought holds that merit rating and job evaluation use the same yardsticks, that the factors of job evaluation are selected with the intent that the degree of satisfaction of the job requirements by the individual are rated by those factors, and that the complete qualitative rating is obtained in this manner. The combined formula for job evaluation and merit rating herein described was developed in accordance with that purpose.

MECHANICS OF MERIT RATING: Merit rating is a formal procedure conducted at regular intervals to



Photo, courtesy Allis-Chalmers Mfg. Co.

". . . the creative engineer must be able to express himself clearly, logically and accurately, verbally and in writing . . . edit reports, address large groups and train incumbents . . ."



Photo, courtesy, "Flying A", Aeroquip Corp.

"... necessary knowledge of prior art ... comes also from study of recorded art in trade and technical papers and periodicals, patent specifications, catalogs, expositions and exhibitions ..."



Photo, courtesy "Flying A", Aeroquip

"... technical perfection being unattainable ... requires an inherent instinct or respect for perfection which goads the engineer on until practical perfection has been achieved ..."



Photo, courtesy National Cash Register Co.

"... dexterity is employed ... to a considerable extent by creative engineers in examining, operating and testing mechanisms ..."

assess the performance, qualifications, progress and deficiencies of all personnel in the group covered by the procedure. In most cases, this interval is twelve months and the rating immediately precedes the annual, across-the-board adjustments of wages and salaries. Where circumstances require, the procedure may occur at six-month intervals but rarely at a lesser interval. At the other extreme, the interval may be eighteen or twenty-four months but rarely longer.

The merit rating procedure must be conducted on an open-and-aboveboard basis with all employees knowing that they are to be rated, when they are to be rated, by whom they will be rated, what the rating formula is, and what the outcome of the rating will be. Insofar as it is possible, each employee should be rated by more than one supervisor, i.e., when the employee's performance during the period rated is known to more than one rater.

Nearly everyone has certain prejudices, strong or weak, which will effect his rating. These prejudices may relate to sex, color, religion, mode of dress, political affiliations, and many other influences which have nothing whatever to do with an individual's qualifications and performance. Since two or more raters will not have the same prejudices to the same degree, the effect of multiple rating is to disclose them so that they can be discounted and so that the individual's true merit can stand out clearly.

A practice which has been fruitful of healthy morale in many cases is to reveal to each employee his composite rating, after necessary adjustments, and to discuss the rating, factor-by-factor, with the employee in an honest and constructive manner. This practice informs the individual of his deficiencies so that he may undertake to correct them. The individual's response to this practice is, itself, indicative. He may respond emotionally, refuse to accept the ratings and give evidence of inability to adjust himself. The opposite response, objective, constructive and realistic, is a healthy indication.

The individual who responds objectively, constructively and realistically and who gives good reason for rejecting the ratings should have the right to appeal to higher authority. This appeal may consist of a written statement presented to a committee consisting of the individual's immediate supervisor, an engineering executive or administrator and a qualified representative of the personnel department. After adequate review of the appeal statement and such oral evidence as may be appropriate, the committee's finding should be final and acceptable to the employee.

". . . members of a creative engineering force bear definite responsibilities which generally are heavier than . . . in other fields . . ."



This procedure may well be used where demotion or involuntary separation is pending.

MERIT RATING STANDARDS: In rating the individual by job classification factors such as previously described, the rater finds for each of the thirty-four factors, the degree-description which, in his opinion, best states the individual's performance and demonstrated capacity. This is apart from the degree of the factor which is demanded by the job the individual happens to occupy. To illustrate with a few examples: In rating a junior industrial designer whose position requires *below-average* resourcefulness with point value of 24, the individual may have demonstrated the ability . . . "occasionally or intermittently to find and adapt the means of accomplishment in the *normal* degree of a single industrial art" instead of ". . . in a *limited* variety of a single industrial art." In this case, instead of rating the individual 24 points for resourcefulness, he would be rated 36 points at the *average* level.

In rating a junior engineering designer on adaptability where his job requires 30 points for his factor, it may be found that he has not succeeded in adapting himself "Frequently . . . . to normal variety of conditions within one branch of creative engineering art" but has succeeded in doing so only "occasionally . . ." In this case the individual would be rated below his job requirement, at 20 points.

In rating a junior tool designer on ability in organization, whereas this job contains no requirement for this ability, it may be that the individual has had the opportunity to demonstrate a minimum of this ability and has demonstrated that ability. Thus he would be given a rating on a factor not required in the position he occupies.

The rule is, then, that each individual is rated under every job factor including those not required in the job he happens to occupy. Also, he is rated solely in accordance with the degree-descriptions under each job factor, regardless of the degree required by his present job. Many individuals never have an opportunity to demonstrate abilities under certain job factors. For example, few individuals are permitted to participate in formulation of policy, in the jobs they now occupy, and they must advance one or several grades before having this opportunity. Where opportunity has not existed to demonstrate certain abilities, the rating automatically is zero.

The method of rating in terms of specific degree-descriptions helps largely to avoid the colorings of prejudice and to encourage fair and just ratings. In case the rater has not observed the individual's abilities under a job factor, and cannot have a useful opinion on those abilities, he should rate the individual at the degree-value for the job which the individual occupies, and indicate that the rating is arbitrary but not based upon personal observation. Other ratings on the same individual and factor, where available, are given greater effect. It must be presumed that the individual could not have demonstrated a markedly greater or less ability, in the job factor, than is required in his job, without the fact being noted by a rater.

A common practice in professional or captive creative engineering is to create a team for each project, under the direction of a project manager and consisting of such personnel as will be needed to complete the project, and these personnel are drawn from a pool containing all available engineering personnel. In addition to the permanent team which stays with the project from beginning to end, others may be added from time-to-time and for short intervals. This system makes it possible for an individual's abilities and performance to be observed by supervisors of two or more projects between rating periods, and two or more independent ratings can be made on the same individual. While these supervisors may exchange their interpretations of an individual's performance, neither may announce his rating to the other.

The rater is supplied with a "Periodic Merit Rating" form for each individual to be rated, and the form should contain the rating on each job factor which was given the individual the last time he was rated. This previous rating helps the rater to crystallize his view of the individual's ability in terms of the advancement which has been made since the last rating.

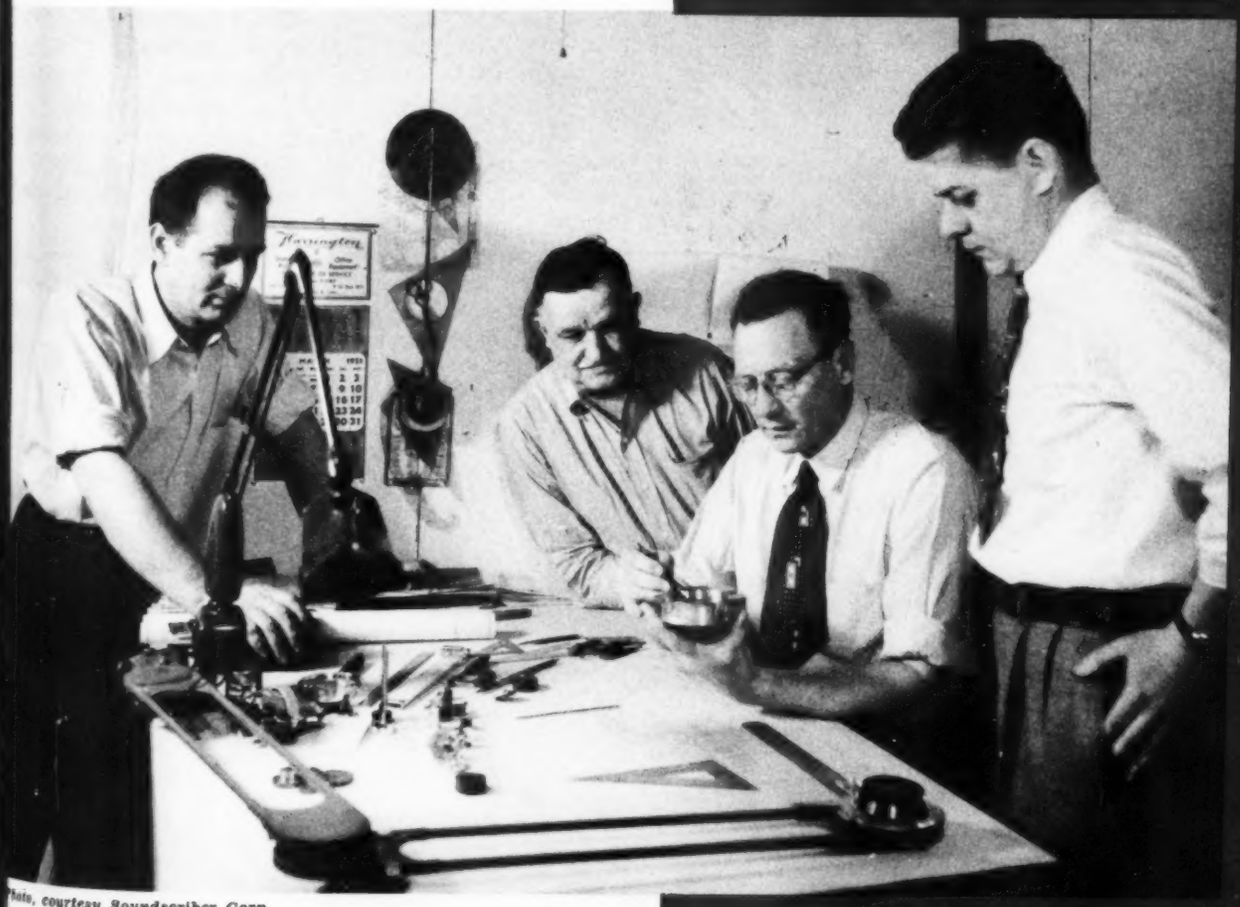
The rating is made on the "Periodic Merit Rating" form by encircling the point value for every job factor which, in the rater's opinion, indicates the degree-description which best fits the individual's merit. Where the rating is not the result of the rater's own observation, but is the job rating applied arbitrarily, the rating should be indicated as by a cross within the circle for that factor. Zero ratings appear as no markings for the factor. The rater also completes the reverse side of the form by commenting freely on the five questions which appear there.

INAUGURATION OF MERIT RATING: Until a rater has been through several rating procedures, he will approach the task with some fear and trepidation. Only the most callous of supervisors are able to discount the responsibility borne by merit raters. A detailed manual of rating procedure should be prepared containing explicit information and helpful suggestions, and copies should be presented to all raters in advance of the rating program. Group conferences may be held in advance by the raters who can present their questions and obtain further enlightenment and assurance.

Initially, ratings of individuals may be considered tentative at the rater's request, until the composite ratings have been computed. Thereafter, where one rating is out of line with one or more other ratings on the same individual, the former may be re-considered by the rater concerned, with the privilege to amend his rating.

Reluctance will be felt to control pay rates according to the first merit rating efforts. Where uncertainty exists, it is better to defer adjustment of pay rates according to merit rating until the whole organization has found adequate confidence in its merit rating ability. Even after considerable experience with merit rating, some organizations never use it to control pay rates but still get good value from merit rating in training programs, constructive coun-

". . . an unemotional, impersonal and objective attitude is needed to withstand criticism, ignore that which is unfounded and profit from that which is useful . . ."



Photo, courtesy Soundscriber Corp.



sel to employees, and as one of several indices used as guides in making transfers and promotions. In general, the third consecutive experience with merit rating brings an organization to ample confidence in its ability to rate its staff fairly.

Conclusion: This article seeks to convey two simple ideas. First, our indispensable creative engineers, designers and technicians deserve clear recognition of their value to the industrial economy, no less than file clerks, carpenters, drill press operators and bench hands. The modern accepted form of recognition is job evaluation and merit rating. Second, the application of job evaluation to creative work is not easy and few applications have been made as yet. However, the applications of the fundamental principles have been tested and ways have been found to classify and evaluate the essential components of creative work.

Any procedure which works well in one place under one set of conditions probably will not work in another place however similar. No greater error could be committed than a verbatim application to another engineering organization of the particular job factors, job point values and point-pay relationships that have been described in this article. Each job evaluation program must be molded to fit the precise requirements and limitations of the organization in which it is to be used.

This is not to say that no single job evaluation program can be applied to two or more separate creative groups. A larger company having engineering groups in two or more of its branch offices, plants or temporary field offices could apply the same job evaluation formula to all groups. Such a formula would have to take into account the important conditions of all offices, plants and branches as if they were one completely integrated force.

In these times of pressure for rearmament and the attendant competition for creative skills, job evaluation and merit rating can become a powerful force for stabilizing engineering staffs.

Single copies of this article may be obtained, as long as the supply lasts, by writing MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

Design Factors for Stress Concentration

Part 4—Fillets in Tension and Torsion

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Research Laboratories
Westinghouse Electric Corp.
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CALCULATION methods and nomenclature related to stress-concentration factors were outlined in Part 1 of this series, published in February. Examples of filleted members subjected to tension are shown in *Fig.* 18. In torsion, the examples shown for bending in *Fig.* 12 (Part 3, May) also apply.

Stress-concentration factor, K_t, for a filleted flat bar subjected to tension, *Fig.* 19, is based on photoelastic tests by Frocht.[1, 2] For a filleted shaft subjected to tension, *Figs.* 20 and 21, stress-concentration factor, K_t, and shear-energy factor, K_t', have been derived by the same method described in Part 3 last month. With this method, each factor to be determined has been computed by simple proportion from established data for other cases.

Factor K_t for filleted shafts in torsion, *Fig.* 22, is based on two sources. For r/d values from approximately 0.01 to 0.1, experimental values determined with an electrical analogy method by Jacobsen[3] have been employed. Values determined with precision strain gages by Weigand[4] have been used for r/d values ranging from 0.1 to 0.25. For members in torsion, K_t and K_t' are the same.

The final part of this series, dealing with transverse holes, will appear next month.

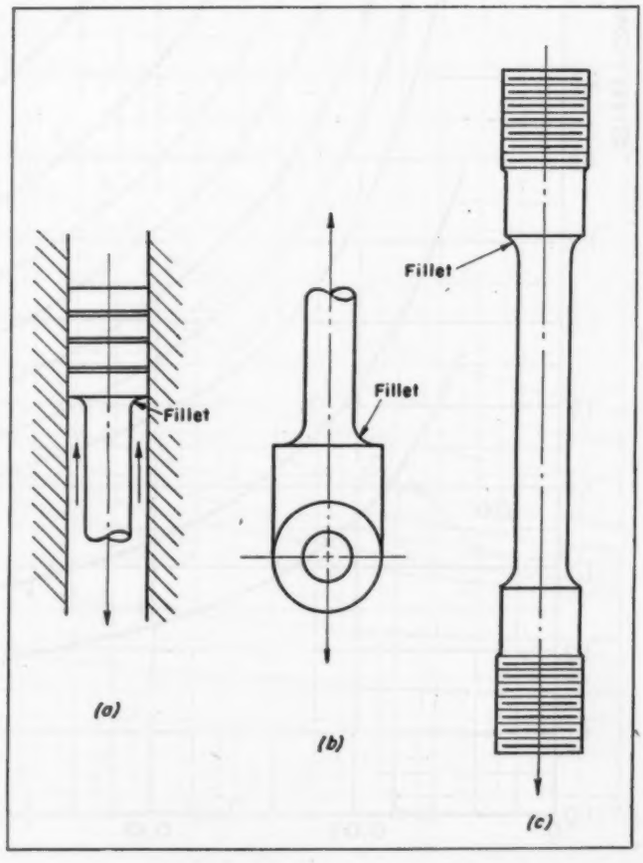


Fig. 18—Examples of filleted tension members. Shown at *a* is a hydraulic actuator, at *b* an eye bar and at *c* a test piece or dynamometer bar

REFERENCES

1. M. M. Frocht—"Factors of Stress Concentration Photoelastically Determined," *Trans. ASME*, Vol. 57, 1935, Page A67.
2. M. M. Frocht and D. Landsberg—"Factors of Stress Concentration in Bars with Deep Sharp Grooves and Fillets in Tension," *Proc. SESA*, Vol. VIII, No. 2, 1950.
3. L. S. Jacobsen—"Torsional Stress Concentrations in Shafts of Circular Cross-Section and Variable Diameter," *Trans. ASME*, Vol. 47, 1925, Page 619.
4. A. Wiegand—"Ermittlung der Formziffer der auf Verdrehung beanspruchten abgesetzten Welle mit Hilfe von Feindehnungsmessungen," *Luftfahrt-Forschung*, Vol. 20, 1943, Page 217 (NACA Translation No. 1179).

Curve sheets appearing in this article, together with additional design data, will appear in a forthcoming book to be published by John Wiley & Sons Inc., New York.

Data Sheet

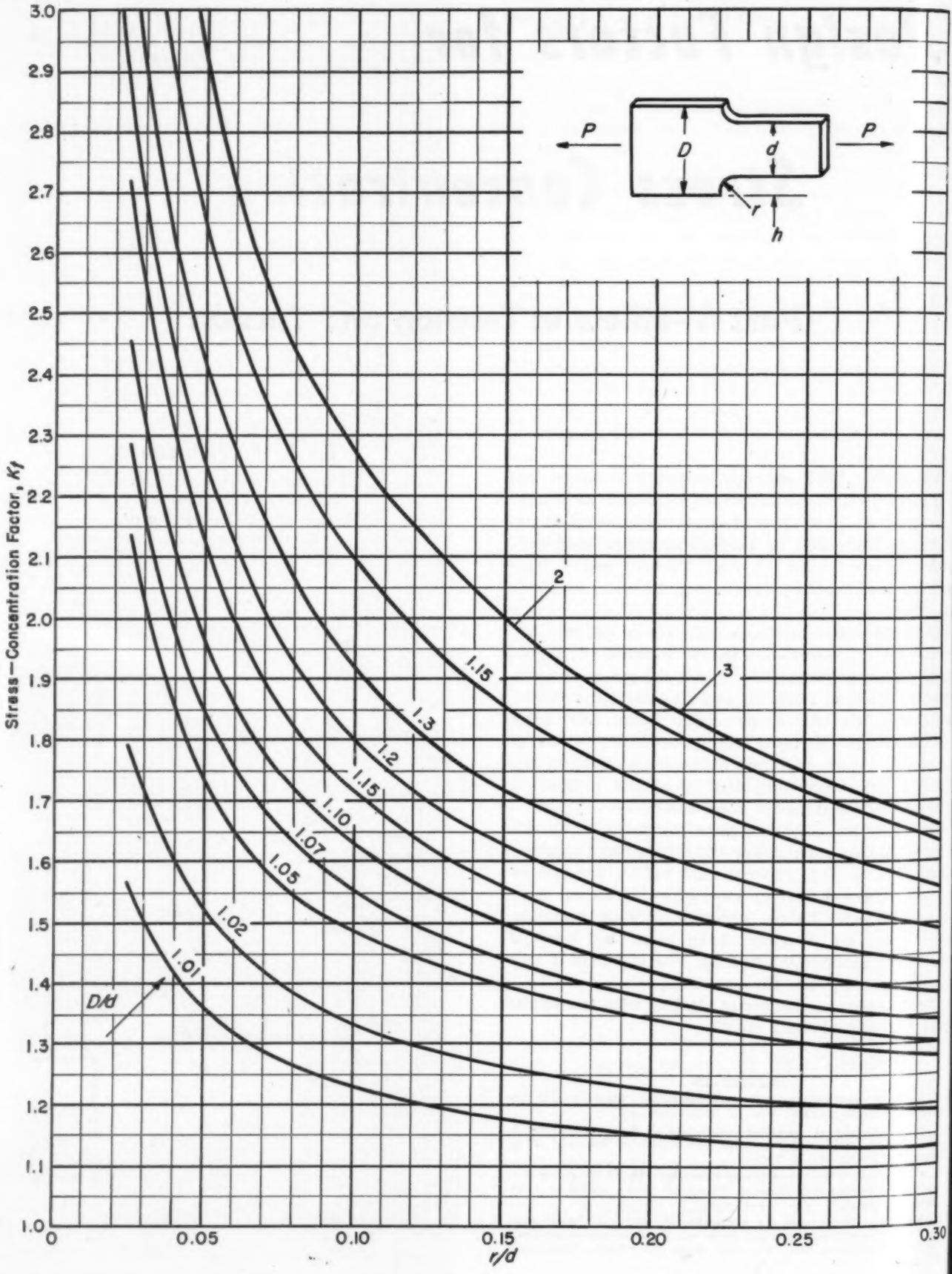


Fig. 19—Stress-concentration factor, K_t, for filleted flat bar in tension. Curves are based on photoelastic data of Frocht

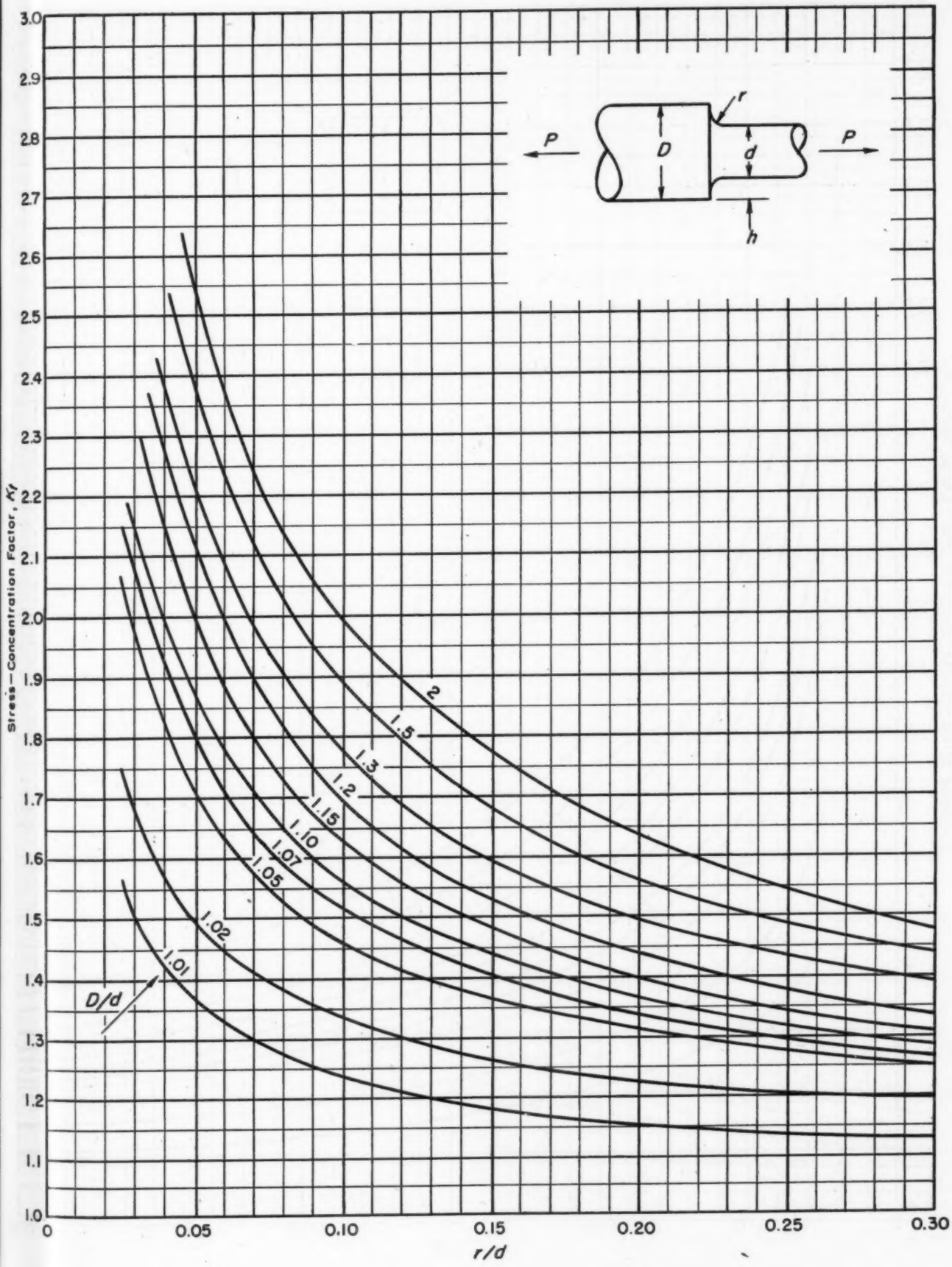


Fig. 20—Stress-concentration factor, K_t, for a filleted shaft in tension

Data Sheet

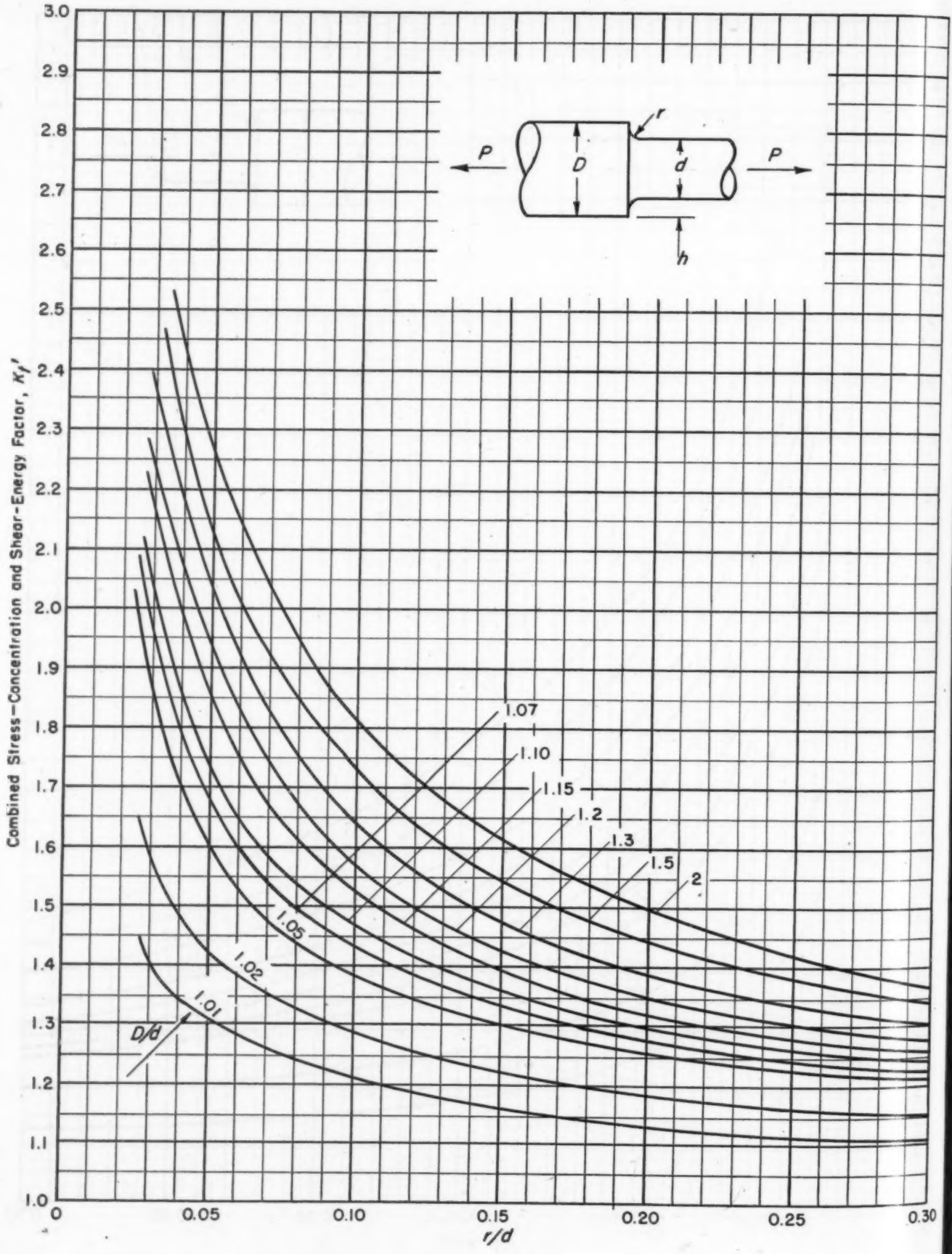


Fig. 21—Combined stress-concentration and shear-energy factor, K_t', for a filleted shaft in tension

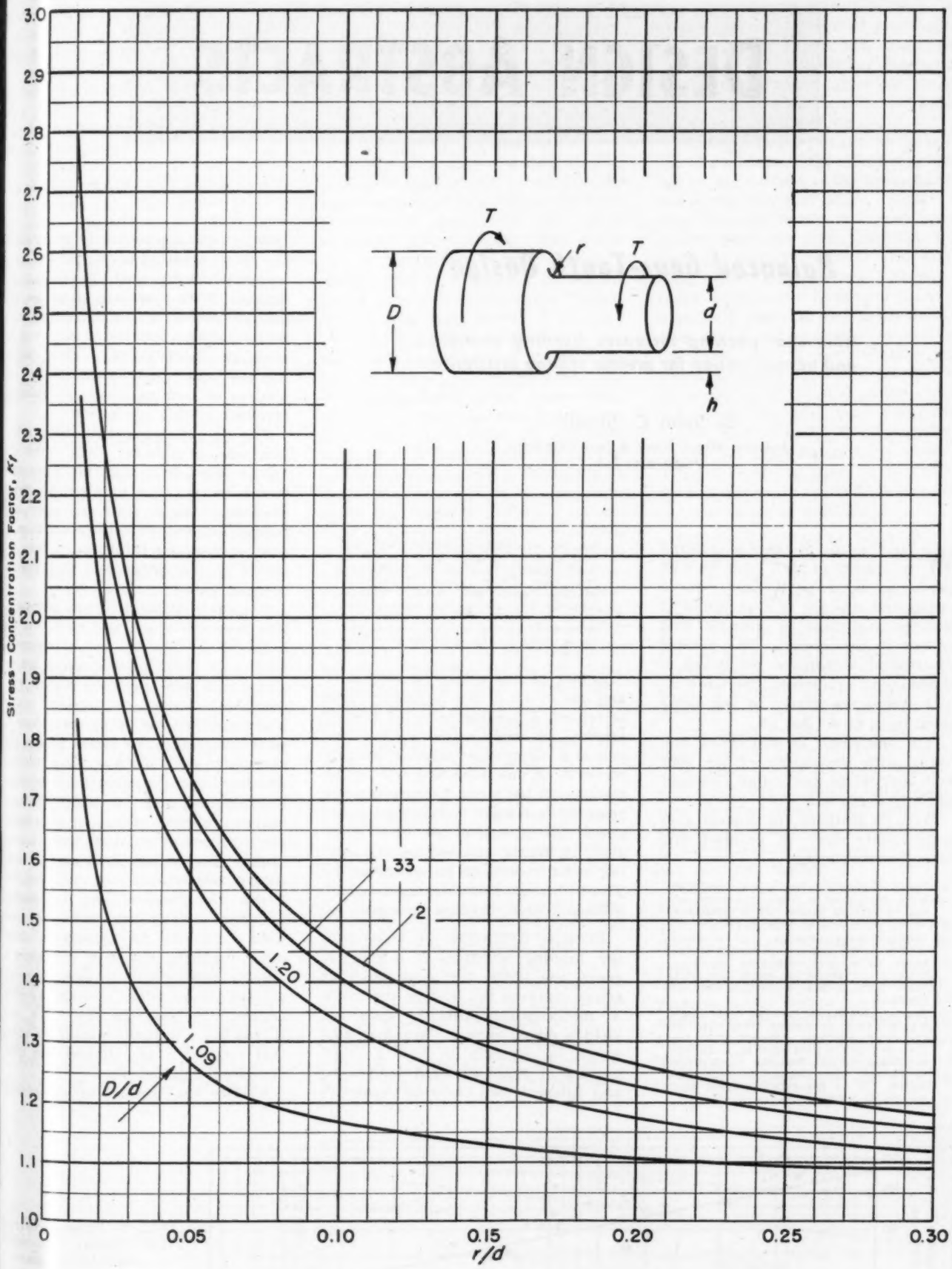


Fig. 22—Stress-concentration factor, K_t, for a filleted shaft in torsion. Curves are based on experimental values of Jacobsen and of Weigand

DESIGN ABSTRACTS

Balanced Gear-Tooth Design

How shot peening increases bending strength and permits design for greater scoring resistance

By John C. Straub

American Wheelabrator & Equipment Corp.
Mishawaka, Ind.

WHEN a pair of gears is required to operate at high loads or high speeds or both, particularly where weight and size are at a premium, it becomes important to consider shot peening in the design. The greater the required horsepower per pound of transmission equipment, the more vital becomes the design of the gears called upon to do the job.

This discussion is concerned primarily with the design of the gear teeth themselves, particularly on spur and helical gears.

TYPES OF FAILURE: In general, gear tooth failure may be grouped into three classifications:

1. *Tooth breakage:* An entire tooth or large portion of a tooth is broken out due to bending stress. It is commonly known as a fatigue type of failure
2. *Pitting:* Characterized by pits or small craters in the contacting surface of the tooth. It is usually found on the pinion tooth at or somewhat below the pitch line. This is also a fatigue type of failure
3. *Scoring:* Sometimes referred to as spalling, scuffing or galling, this type of failure is distinctly different from the first two and is evidenced by a decided roughness on the working tooth flank as though the mating surfaces had seized. It is generally accepted that scoring is actually the result of welding the two surfaces together and then tearing them apart. It is caused by high compressive stress in combination with high sliding velocity of the tooth surfaces upon each other. Whereas bending and pitting failures are most likely to occur after a considerable amount of service, scoring is most likely to occur in the early stages of operation, if at all.

A pair of gears may be subject to any one or all of the foregoing types of failure, depending upon the type of service. In some cases this may result in a compromise between bending strength on one hand and scoring resistance on the other, because in some respects a design factor may favor one at the expense of the other. However, in highly stressed gears, scoring resistance may be increased by proper design consideration which utilizes greater bending strength.

BENDING STRENGTH: In computing the bending strength of a pair of gears, one of the first questions that arises concerns the load on the teeth. A mathematical analysis does not yield a direct answer. Another way would be actually to test a large number of gears of different designs and different load carrying capacities under conditions as nearly as possible like those obtained in the actual service for which the gears have been designed. With complete data on the test procedure, cycles to failure, and design information, the results can be analyzed statistically. This latter method was used in selecting the method of bending stress calculation involved in this discussion.

The procedure used in this selection was as follows: Data were obtained direct from different manufacturers on a large number of dynamometer fatigue tests on spur and helical automotive type transmission gears. Complete information was obtained on the design and test result of each pair of gears.

Several methods of stress computation were then set up, each on the basis of a different set of assumptions. In order to determine which, if any, of these methods would give consistent results, a "stress" value was computed for every gear included in the tests. The stress values obtained by each method were plotted on a log-log chart against the average number of cycles at which fatigue failure occurred. Some of the methods of stress calculation were immediately disqualified because no consistent relationship was obtained between the "stress," as calculated, and the fatigue life from the test data. Results as calculated from other methods, however, did show a definite relationship between the calculated stress values and the average fatigue life from the test data, and it was not a difficult matter to select that method which showed the most consistent relationship.

Finally the method of calculation

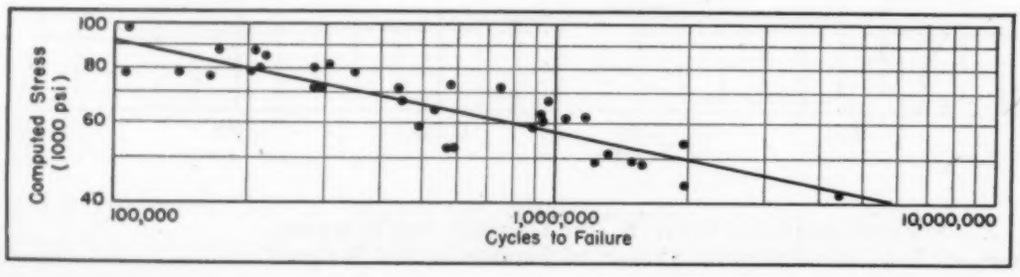


Fig. 1—Fatigue chart of 155 helical automobile transmission gears

elected was based on the assumption that the load is distributed uniformly on the average total length of contact lines. The tooth strength factor is obtained from a layout in the section normal to the tooth, with the load applied at the tip of the tooth in the same manner as originally described by Wilfred Lewis. A complete description of this method of calculating bending strength was published some years ago.

An appraisal of the effectiveness of this method can be obtained from the chart of *Fig.* 1, which shows the relationship between the calculated stress and the average life of the gears as determined by the dynamometer tests. Included in the chart are 155 tests on a variety of designs. All tests represented in *Fig.* 1 were made on gears of approximately 60 Rockwell C surface hardness, with no surface treatment other than the heat treatment itself.

Data May Suggest Redesign

By this method, the design of a proposed pair of gears can be analyzed, and in some cases an appreciable gain in fatigue strength can be obtained by changes in the tooth proportions. For example, the requirements might permit a decrease in the diametral pitch or an increase in pressure angle, either of which would decrease the bending stress.

It is quite evident, of course, that any strength calculation cannot be expected to overcome poor manufacturing practice. A number of factors in processing can seriously affect the life of the gears. One such factor is the nature of the tooth fillet, with regard to stress concentration resulting from deep tool marks. Deep grooves in the tooth fillet can be more serious than the stress concentration because of the fillet itself. To minimize this condition it is good practice to use a chamfer, or better still, a rounded corner on the hob or cutter.

SHOT PEENING: In gears which are intended to carry high stresses, a pronounced increase in fatigue strength can be obtained by shot peening the teeth. Effectiveness of shot peening in overcoming fatigue failures in a given design of a machine part is well known. But its advantages in designing for greater fatigue strength and greater utilization of material are often overlooked. The increase in allowable stress for a given fatigue life requirement will vary with that life requirement. That is, the greater the required life, the greater will be the benefit derived from shot peening. However, even under severe requirements, an increase of 10 per cent in allowable stress is conservative.

In *Fig.* 2 is shown a fatigue line, similar to that of *Fig.* 1, based on the same method of calculation, but from considerably more data than those originally accumulated. The lower line is comparable to that of *Fig.* 1 except that it represents carburized gears only and is somewhat higher. The original data in *Fig.* 1 included carburized gears as well as through-hardened and cyanided gears. Although the test points for the through-hardened gears were somewhat lower than for those which were carburized, there were not sufficient data at that time to distinguish between these two groups. More recent data on carburized gears have indicated that there is a distinct advantage in carburized gears as compared to those which are through-hardened and cyanided. It would therefore be expected that results on through-hardened gears would fall below the average line. The upper line of *Fig.* 2 shows the average life in relation to the calculated stress for shot-peened carburized gears. In all cases, peening was the last operation insofar as the teeth are concerned, and no attempt was made to protect the tooth flanks from the blast.

Strength and Life Increased

It can be seen from the chart that, for example, an average life of 800,000 cycles is obtained on nonpeened gears at a calculated stress of 71,000 psi. For the same average life, the allowable stress for shot-peened gears is 88,000 psi, or an increase of more than 24 per cent in allowable stress. From the standpoint of increase in life at a given calculated stress, it can be seen that at a calculated stress of 80,000 psi, the average life of nonpeened gears is 300,000 cycles, and that of shot-peened gears 3,000,000 cycles, or an increase of 1000 per cent in life.

Shot peening is equally effective on gears of lower hardness and, of course, on other types of gears such as spiral bevel, hypoid, etc. Sufficient data are not available for stress-life charts on the other types but an increase of 10 per cent in allowable stress is quite conservative.

Although shot peening is usually the last operation, the slight roughening of the surface of the tooth flanks has no detrimental effect. Actually, some manufacturers feel that shot-peened gears are more quiet running than nonpeened gears of the same design and manufacture. In some cases, however, it is desired to have a smooth finish on the tooth flanks. This can be accomplished by cutting the teeth with a protuberance hob, which produces an effect similar to undercutting at the root of the tooth. The gears are then hardened, shot peened and ground. This procedure allows the tooth flanks to be ground without removing any of the shot-peened surface in the fillet where the bending stress is maximum.

PITTING RESISTANCE: Data on pitting resistance are not as plentiful as in the case for bending strength, primarily because of the difficulty in obtaining quantitative data. Bending failures can be easily recognized while the gears are running, because of the sudden noise. Pitting on the other hand is a slow progressive failure, starting with extremely small craters in the tooth profile. In some cases these craters grow larger and more numerous until, finally, enough material is removed to cause complete failure. In other cases it may develop as very small pits which progress to a moderate degree and then stop without any real damage.

Wickendon, Brophy and Miller have been successful in establishing some quantitative data, and in determining the life of gears at which pitting begins. It is rather generally accepted that pitting is the result of high compressive stress, but to my knowledge there are not sufficient data available to establish the validity of any method of calculation on the basis of actual fatigue tests. A value of

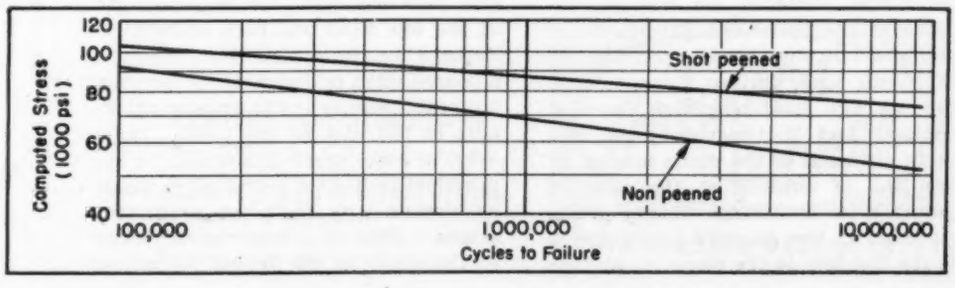


Fig. 2—Fatigue chart of carburized automative type spur and helical gears, shot-peened and nonpeened

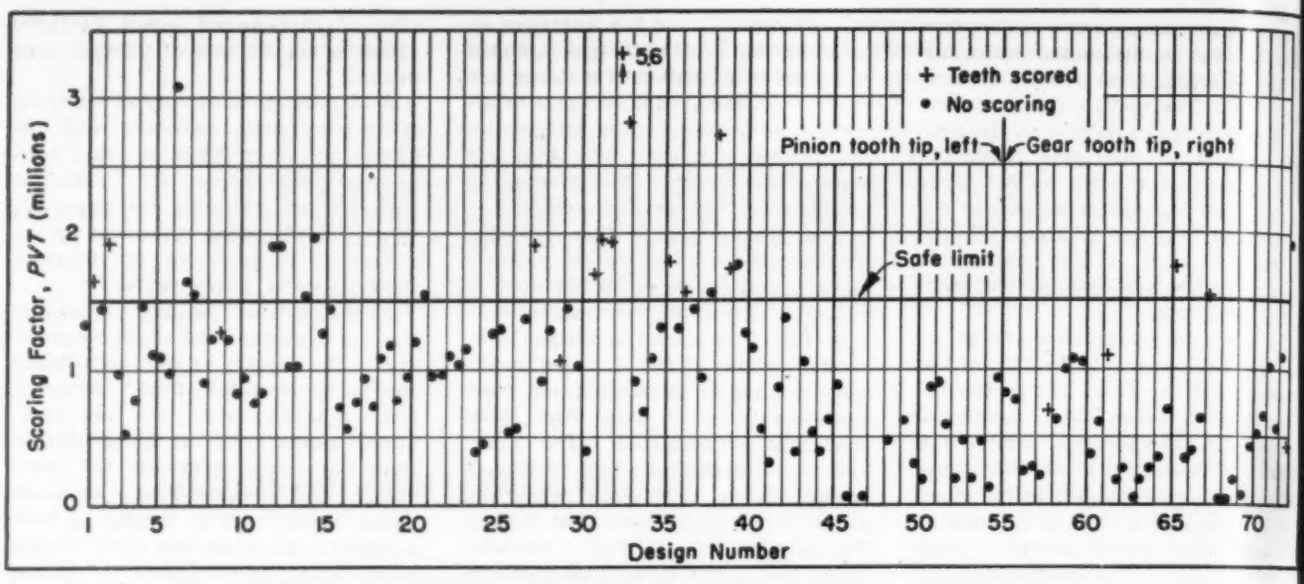


Fig. 3—Correlation of scoring factor, *PVT*, with actual tests on 73 gear designs

maximum compressive stress can be obtained by a method described later in this discussion. A limiting value of 200,000 psi has been used with some success. This is a qualitative value, but it is believed to be on the conservative side.

SCORING RESISTANCE: Scoring is caused by a combination of high compressive stress and high sliding velocity on the contacting tooth surfaces. By means of an approach similar to that described in appraising the bending strength formula, a method of calculation of scoring resistance in spur and helical gears was developed by the author, under the direction of J. O. Almen at the Research Laboratories Division, General Motors Corp. Dynamometer test data were accumulated on a large number of gears, along with complete design information. With these data at hand, various assumptions were made until good correlation was obtained between calculated values of scoring resistance and the actual test data. Briefly, the method selected is based upon the same assumption, with regard to distribution of the transmitted load, as that used in the bending strength calculation discussed previously.

The method consists of the calculation of the product, *PVT*. Here, *P* is the maximum compressive stress as determined by the Hertz equation for cylindrical surfaces, for a point located at the tip of the gear tooth or pinion tooth, and based upon the total tooth load derived from torque, the average total length of lines of contact, and the curvatures of the tooth surfaces in the plane normal to the line of contact at the selected point; *V* is the sliding velocity of the surfaces at the selected point; and *T* is the distance in the plane of rotation from the pitch point to the selected point. Simplified formulas for the calculation of *PVT* are given in the appendix.

The degree of correlation of the calculated values with actual test results can be seen from the chart of *Fig.* 3. Data shown in this chart represent actual test results on well over 50,000 pairs of aircraft gears. The gears tested covered a wide range of requirements. The torque requirements varied from a few pound-feet up to several thousand pound-feet, and the speed requirements ranged from a few hundred rpm up to 28,000 rpm. All test data accumulated were on fully hardened spur gears, lubricated with mineral oil. External as well as internal gears were included.

Safe PVT Limit Shown

Note that, by and large, those gears which have a calculated *PVT* factor in excess of 1,500,000 failed by scoring, whereas those with a *PVT* factor of less than 1,500,000 had no scoring failure. It should be mentioned that with extreme pressure lubricants, a value of *PVT* in excess of 1,500,000 may be used.

BALANCED DESIGN WITH SHOT PEENING: A study of the design considerations from the standpoint of both bending strength and scoring resistance reveals that there is some conflict between high bending strength on the one hand and high scoring resistance on the other. For example, a coarse pitch is desirable for bending strength because of the greater thickness at the root of the tooth. However, in some cases this would be impractical because a coarse pitch would necessitate long teeth for continuous action. This, of course, would mean an increase in the length of action and, consequently, higher sliding velocity. Furthermore, with long teeth, particularly in high ratio gears, tooth action approaches the base circle of the pinion which in turn results in a high compressive stress because of the small radius of curvature of the pinion tooth in that region. In such a case, an increase in bending strength may lead to scoring tendencies. Therefore, in order to obtain satisfactory operation with minimum weight, it may be necessary to compromise between bending strength and scoring resistance. This leads to a logical question as to the usefulness of shot peening relative to scoring resistance. For a given design, experience indicates that shot peening has little direct influence on the scoring tendency of gears of the same design and operating conditions. However, since a balanced design may involve a compromise between bending strength and scoring resistance, a distinct advantage can be gained by designing the gears with a finer pitch in favor of scoring resistance. This would result in decreased bending strength, which can be restored by shot peening. By this reasoning it can be seen that shot peening can be used directly for increasing bending fatigue strength, or indirectly, by proper design consideration, for increasing scoring resistance.

APPENDIX: The nomenclature used in the calculations is as follows:

C = Center distance, inches
F = Face width, inches
n_p = Pinion speed with respect to its own axis, rpm
N_p, N_G = Number of teeth in pinion and gear
P_p, P_G = Maximum compressive

(*Continued on Page* 218)

JOHNSON BRONZE

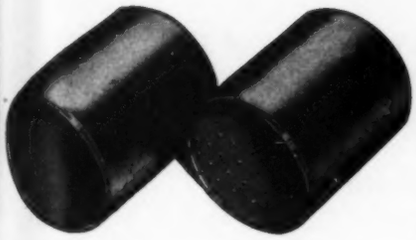
SLEEVE BEARING DATA

Bearing TYPES

JOHNSON BRONZE

SLEEVE BEARING DATA

Sheet Metal Bearings-1



SHEET METAL BEARINGS, sometimes referred to as either thin wall, rolled-up, slip-in, split or laminated, are available in four different types, i.e.:

1. Bronze sheet metal
2. Bronze-on-steel
3. Steel and lead babbitt
4. Steel and tin babbitt

They are comparatively low in price . . . particularly when there is quantity of a size . . . yet high in efficiency, possessing many unusual bearing qualities. With the exception of certain automotive replacement parts, sheet metal bearings are not stock items but are made to specifications determined by the requirements of the application.

Bronze Sheet Metal

The necessity for ductility limits bronze sheet metal bearings to two alloys, containing not more than 4% lead and 4% tin. Higher percentages of these metals would render the material too hard for rolling. As listed below, Johnson's alloy No. 44 is the highest grade and comes closest to plastic bronze. Due to the limitations of the elemental constituents these two alloys have a higher coefficient of friction and not quite as great load carrying capacity as cast bronze. However, the rolling operation imparts a dense structure to the metal which results in excellent resistance to pounding and to shock. The degree of hardness can be furnished as specified.

Bearings made of number 40 alloy should be burnished in place as the metal has low machining qualities; however, number 44 alloy can be burnished, bored or reamed in assembly.

The most common wall thicknesses are 1/32" and 1/16", with a variation of .005" plus or minus from the nominal size. One of the advantages of limiting the wall thickness to 1/16" is that the bearing can be easily seated in place by burnishing. Oil holes, slots or grooves are easily added during the fabricating process.

Bronze Sheet Metal bearings are excellent for applications where motion is comparatively low and impact is the main factor. They are also ideal and most economical for use where atmospheric or gaseous conditions may corrode cast iron or steel.

	Johnson Alloy No. 40 S.A.E. 795	Johnson Alloy No. 44 S.A.E. 791
COPPER	90.0%	86/90%
TIN	0.5%	3.0/4.5%
LEAD		3.5/4.5%
ZINC	9.5%	3.5/5.0%
HARDNESS ROCKWELL B 65-71—1/16 Ball 100 KG. LOAD		

Burnishing is desirable in all cases when possible for it imparts a dense smooth bearing surface, seats the bearing in place properly and renders the bore uniform. The common stock allowance for burnishing is .002" to .004".

If bearings are to be used in cast iron housings, or other types which may not be strong enough to permit a burnishing operation, it is recommended that a material be used possessing good reaming properties. Sometimes it is necessary, due to design of application, to ream two or more bushings in line. Reaming stock allowance should be about .006" to .009".

In cases where any doubt exists regarding the best method of sizing sheet metal bearings in assembly, it is advisable to submit complete data to our engineers. We will draw on our vast experience and give you a straight-forward answer for your particular problem without obligation. In some cases we often find it advisable to submit samples for test application in order to be absolutely certain that the correct solution has been found before fabrication of the complete order.

Points to remember when ordering

1. Housing hole size and housing material.
2. I.D. required after finishing in assembly.
3. Method of finishing I.D.
4. Shaft diameter and tolerance.
5. Special features such as grooves and holes should be specified.

Thrust Washers

Bronze sheet metal is an ideal material for various types of washers, thrust plates and other flat pieces. As such it is available either in the form of the completed product, made to exact specifications or in rolls for fabrication by the user. This material can be secured either plain, serrated for graphite, or ball indented for the retaining of grease.

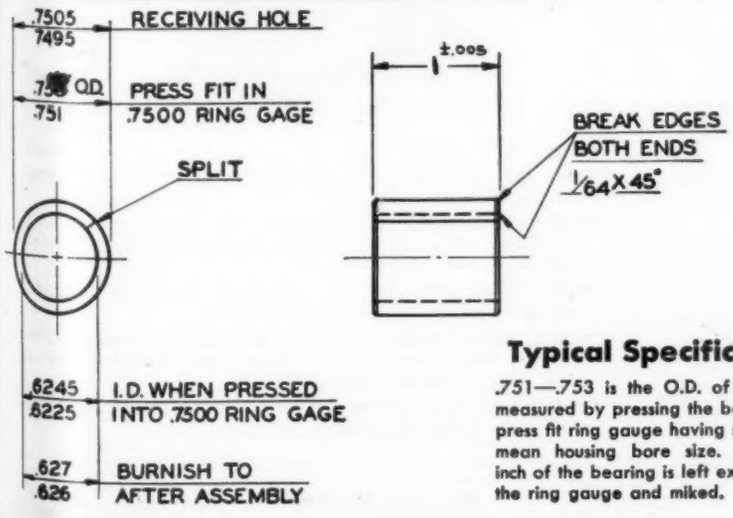
Johnson engineers are always available for consultation on all types of bearing problems. Their advice is available without obligation.

●

This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze

SLEEVE BEARING HEADQUARTERS
525 S. MILL ST. • NEW CASTLE, PENNA.



Typical Specifications

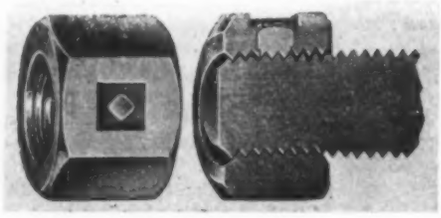
.751—.753 is the O.D. of the bearing measured by pressing the bearing into a press fit ring gauge having size equal to mean housing bore size. One-quarter inch of the bearing is left extended from the ring gauge and miked.

NEW PARTS AND MATERIALS

. . . presented in quick-reference data sheet form for the convenience of the reader. For additional information on these new developments, see Page 197

Locknut 1

Townsend Co., New Brighton, Pa.



Designation: Nylok Type E

Style: Cold forged nut, extruded nylon lock

Size: American Standard light (E-6) and light-thick (E-7) series, ¼, $\frac{5}{16}$ and ⅜-in. in coarse and fine pitches

Service: Heavy-duty self-locking fastening against vibration; low-torque installation; temperatures from −400F to +250F; lock unaffected by most commercial chemicals

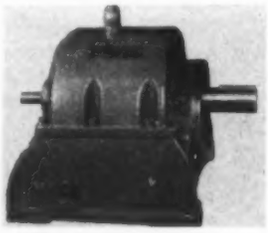
Design: Nut double chamfered to permit installation in either direction; nylon lock plug insert located in one hex face midway between ends of nut, grips threads tightly without galling; reuseable

Application: Critical fastening of machine elements.

For more data circle MD 1, Page 197

Speed Reducer 2

Westinghouse Electric Co., Box 2099, Pittsburgh 30, Pa.



Designation: Type DB

Style: Horizontal, double-reduction; totally enclosed, foot-mounted

Size: 1 to 100 hp

Service: Twelve standard gear ratios from 6.25:1 to 58.3:1

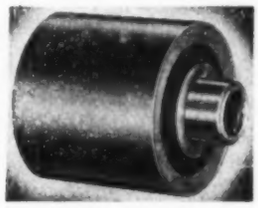
Design: Hobbed, single-helical gears taper hardened; split-construction cast iron housing; simple, positive splash lubrication system; antifriction bearings; average efficiency 96 per cent

Application: For small to medium-size machine drives where prime mover is coupled or belted to gear unit.

For more data circle MD 2, Page 197

High-Capacity Clutch 3

Auto Specialties Mfg. Co., 643 Graves St., St. Joseph, Mich.



Style: Dry disk; sealed unit

Size: Lining diameters $3\frac{9}{16}$ by $2\frac{1}{16}$-in.; clutch overall less clutch release $4\frac{1}{16}$-in. OD by $4\frac{7}{16}$-in. long

Service: Dry clutching service in lubricated environments; operating torque capacity 2200 lb-in.; max design torque exceeds this value by 250 per cent

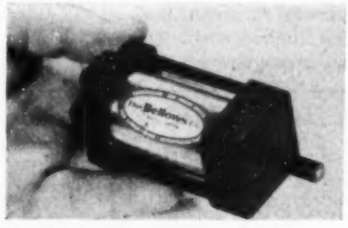
Design: Friction area sealed against transmission lubricant to increase coefficient of friction; energizing force augmented by ball and cone self-energizing arrangement; clutch release by thrust against spring which releases tension on clutch faces

Application: For general machine drives, tractor power take-offs, pump drives, automatic transmissions, etc.

For more data circle MD 3, Page 197

Small Pneumatic Cylinder 4

Bellows Co., 222 W. Market St., Akron 9, O.



Designation: Han-D-Air

Style: Single-acting, spring-return; front flange, rear flange, side, foot, or pivot mount

Size: 1⅛-in. bore, 1-in. stroke; 4⅛ long x 1½ high x 1½-in. wide; $\frac{5}{16}$-in. piston rod with ½-in. threaded end

Service: Power factor 1:1, develops a thrust approximately equal to applied air pressure

Design: Heavy gage pump finish brass cylinder; aluminum alloy heads ⅝-in. thick; oil-resistant piston cup; heavy tension-tested spring

Application: For use in jig and fixture operations and for parts positioning and ejection.

For more data circle MD 4, Page 197

NEW PARTS AND MATERIALS

Hydraulic Pump 5

John S. Barnes Corp., 144 Walnut St., Rockford, Ill.



Designation: Constant-Flo; type GC

Style: Rotary gear; direct drive; standard shaft (model 7100-A-20) or coupling shaft (model 7100-A-26)

Size: 3½ in. wide by 3¼ in. high by 3⅜ in. long; ½-in. pipe ports; $\frac{7}{16}$-in. standard shaft with 1⅜ in. extension and ⅛ by $\frac{1}{16}$-in. by 1 in. long keyway; $\frac{7}{16}$-in. stub coupling shaft slotted with $\frac{3}{16}$-in. extension

Service: 1000 psi continuous pressure, 1500 psi intermittent; hydraulic fluids, lubricants and fuels; 40 to 360 gph; 1200 to 3600 rpm

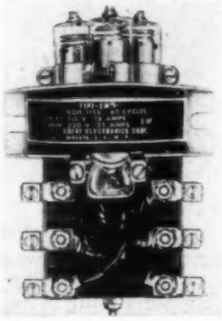
Design: Two-piece heat treated cast iron housing; pump gears from ¼ to ¾-in. face width in ⅛-in. increments to suit capacity desired; needle antifriction bearings

Application: Hydraulic power for machines such as farm tractors, lifts, lift trucks, machine tools, etc.; for power steering systems, torque converters etc.; for pumping fuels, oils, etc.

For more data circle MD 5, Page 197

Plunger Relay 6

Ebert Electronics Co., 185-09 Jamaica Ave., Hollis 7, L. I., N. Y.



Designation: Type Em-7

Style: Mercury contact; hermetically sealed; three-pole, any combination of NC or NO

Size: 4 $\frac{1}{16}$ wide by 5⅜ high by 3 in. deep

Service: 115v a-c, 35 amps max; 220v a-c, 25 amps max per contact.

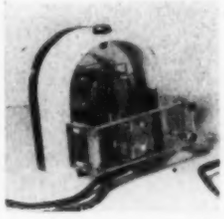
Design: Tungsten contacts hermetically sealed in hydrogen filled glass tubes; three tubes in one coil structure for positive simultaneous contacting; relays withstand over ten million operations without failure

Application: For control circuits in machines.

For more data circle MD 6, Page 197

Electrical Interlock 7

Winterburn Mfg. Co., P.O. Box 386, Putnam, Conn.



Designation: Dazic.

Style: Mercury switches magnetically energized; open or closed construction; model 1020 (stop-start), 1030 (direction indication), 1040 (counting), 1050 and 1060 (fail safe indication), switches NO or NC

Service: Mercury switches rated ½-amp at 125v 60-cycle a-c, 1 amp at 24v d-c; operates from 2 to 20,000 rpm, special gears for lower speeds.

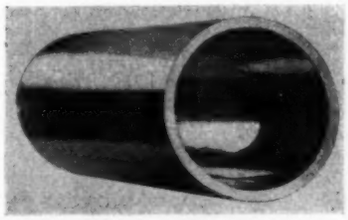
Design: Fluid coupling from drive shaft to magnetic actuating disk, magnetic coupling from disk to vane of mercury switch; Plexiglass drive disk and housing; stainless steel protective case, drive shaft and fill screws; precision ball bearing mounting for moving parts; model 1020—opens (or closes) contacts when shaft starts rotation in either direction, closes (or opens) contacts when shaft stops; model 1030—opens (or closes) pair of contacts with ccw rotation of shaft and closes (or opens) when shaft stops, opens (or closes) second pair of contacts for cw rotation and closes (or opens) when shaft stops; model 1040—makes one impulse per shaft rotation, closing (or opening) contacts approx 18 degrees; Model 1050—combination of 1020 and 1030 for positive zero control; Model 1060—one switch to indicate cw rotation and one switch to indicate ccw

Application: For controlling, interlocking and indicating the rotation of shafts on conveyor idler pulleys, centrifuges, washing machines etc. For signalling, timing and counting machine functions.

For more data circle MD 7, Page 197

Cylinder Tubing 8

Tube Reducing Corp., Wallington, N. J.



Form: Cold finished seamless steel tubing; 1½ to 6-in. bores

Service: Air or hydraulic oils; cylinder parts

Properties: ID of tubing sized to remove scratches, pits and irregularities; mechanical properties greatly improved over hot-rolled or cold-drawn material; no bore machining required with soft packings or leather cups, only light honing for metal piston rings

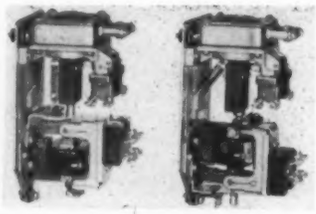
Application: For use as cylinder parts for hydraulic or air actuators; for shock absorbers, etc.

For more data circle MD 8, Page 197

NEW PARTS AND MATERIALS

Timing Relay 9

Square D Co., 4041 North Richards St., Milwaukee 12, Wis.



Designation: Class 9050, type R

Style: Pneumatic; invertible magnet; time delay after energization or de-energization of magnet; with or without dial; surface or flush mount, open or enclosed

Size: 3⅞ wide by 4¼ deep by 7½-in. high (open dimensions)

Service: Timing range adjustable from 0.2-second to 3 minutes; 100 to 600 v, 25 to 60 cycles a-c

Design: Magnet invertible for conversion from delay after energizing to delay after de-energizing or vice versa; enclosures conform to NEMA I, IV and VII designs; accuracy within 10 per cent regardless of voltage, temperature or atmospheric pressure variations

Application: For controlled time delays in electrical systems for machine tools, conveying equipment, and other machines.

For more data circle MD 9, Page 197

Tachometer 11

Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.



Designation: Series 42P

Style: Fixed installation type, three range

Size: Scales full 4 inches long with 100 divisions

Service: Units such as rpm, fpm, in. per sec or any quantity proportional to speed; speeds from ½ to 100,000 rpm

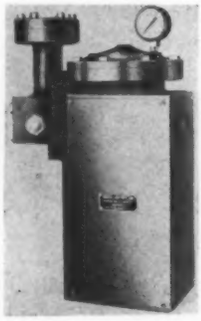
Design: Heavy metal enclosure, black wrinkle finish; knob dial selects any one of three speed ranges over a total range of 40 or 50 to 1; readings down to 1/10 full scale of lowest range; using open wiring, indicator can be located up to 1000 feet from head; calibration adjustable in field; any Metron tach head can be attached

Application: For measuring speed or related values in machines where wide range of measurement is desired.

For more data circle MD 11, Page 197

Flow Signal Transmitter 10

Hagan Corp., Hagan Bldg., Pittsburgh 22, Pa.



Style: Pneumatic; differential measuring

Size: 22.5 in. high by 15 in. wide by 11 in. deep max.

Service: For measuring static pressure, liquid level, or flow differential of liquids, gases or vapors; pressure differentials from 5.5 in. water to 100 psi; static pressures to 1500 psig

Design: Consists of input differential pressure measuring unit force balanced by output system, balancing force originating in modulated loading air pressure resulting from action on escapement pilot valve; accuracy of measurement within 1 per cent of full scale reading

Application: Automatic control, recording or indicating of variables in processing systems, etc.

For more data circle MD 10, Page 197

Force Feed Lubricator 12

McCord Corp., Lubricator Div., Detroit 11, Mich.



Designation: Type F.

Style: Automatic, adjustable; ratchet or rotary drive

Size: 4-quart capacity, 1 to 6 grease outlets; 8-quart, 7 to 12 outlets; 16-quart, 13 to 24 outlets; standard outlet for ⅛-in. copper tubing

Service: Grease; max pumping capacity, 0.2 cu cm per pump stroke; max speed rotary, 500 rpm; ratchet, 300 oscillations per minute; working pressure, 1500 psi max.

Design: Eccentric drive plunger pump; rotary drive interior gear drive ratio, 22.5 to 1 or 45 to 1; friction ratchet gear ratios, 1.5 to 1 or 2.5 to 1

Application: For grease lubrication of cement, steel, mine, chemicals, materials handling, metal working, road and other machinery.

For more data circle MD 12, Page 197



"Gravy ON YOUR HAIR?"

Just because gravy goes swell over noodles, he shouldn't assume it's good on hair, too!

And just because one bearing is best lubricated by one particular grade of oil, you shouldn't assume that the same oil is best for *all* bearings on that machine. In many cases it isn't.

OIL CUPS permit you to lubricate each bearing with the oil best suited to that bearing—thus prolonging bearing life, reducing maintenance costs, cutting down-time, boosting production. And oil cups fortunately *cost very little.*

Gits oil cups have been the standard for industry for more than 40 years. Gits Bros. has the largest selection of oil cups available anywhere. Call on Gits Bros. for a prompt, efficient solution to your lubrication problems.

Write for free Price Guide Catalog

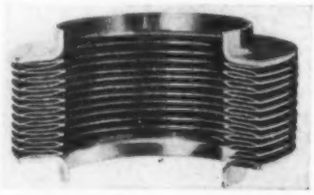
GITS BROS. MFG. CO.

1868 S. Kilbourn Ave. • Chicago 23, Illinois

NEW PARTS AND MATERIALS

Bellows 13

Titeflex Inc., 500 Frelinghuysen Ave., Newark 5, N.J.



Style: Convoluted welded metal diaphragms.

Size: From 1 to 5 inches ID; length, gage, and height of convolutions to suit.

Service: Any heat, pressure or corrosion requirements.

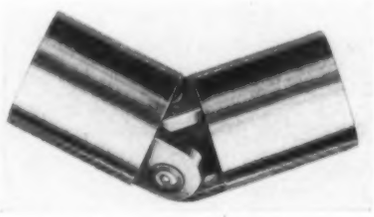
Design: Individual metal diaphragms welded at ID and OD; height of convolutions varied to suit flexibility required in specified length; steel, stainless steels, brass, bronze, Monel, Inconel, etc., to suit environment; inner sleeve liners and fittings can be added.

Application: For absorption of high-frequency vibration and lineal expansion in equipment subject to high-pressure, corrosion or high temperatures.

For more data circle MD 13, Page 197

Universal Joints 14

Gray & Prior Machine Co., Hartford, Conn.



Style: Riveted, bored ends for round, keyway, square, or splined shafts, or to suit.

Size: ¾ through 4-3/16 in. shafts.

Service: Speeds to 3500 fpm. max.

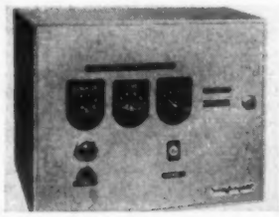
Design: Heat-treated alloy steel construction; stubby jaws and large, equal size bearings provide strength and resistance to jaw spread; sizes over 1½-in. equipped with large grease reservoirs.

Application: For coupling high-speed angular or floating drives in machine tools or similar precision machines.

For more data circle MD 14, Page 197

Electric Counter 15

Production Instrument Co., 702-08 W. Jackson Blvd., Chicago 6, Ill.



Designation: Monitor Automatic Batch Counter

Style: Self-contained, electrical, automatic; 2, 3, 4, and 5 digit

Size: 11 in. high x 7 in. deep x 11 to 22 in. wide (depending on model).

Service: Counts any object or motion that can be arranged to break electrical circuit; counting ranges 1 to 100, 1 to 1000, 1 to 10,000 or 1 to 100,000; 115v 25 to 60 cycle a-c

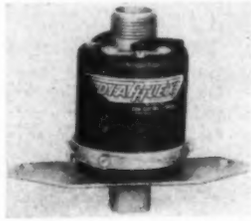
Design: Operates off switch, relay, photoelectric unit or other type circuit breaker; can be located any distance from source of count; equipped with terminal strip for outside wiring connections; three selector dials for count setting; automatic reset

Application: For counting units of repetitive processes; batch counter switch may be used to start or stop electrically operated machinery, conveyers, signals, chute gates, pile changers, kickout devices or other arrangements for marking or separating batches, warning operators, etc.

For more data circle MD 15, Page 197

Pressure Switch 16

Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.



Designation: Diaphlex

Style: Sealed can construction; six styles including hermetically sealed, vented and differential; end or side mounted connector; two-stud, single hole, bracket, or special mounts; SPST, NO or NC, DPDT

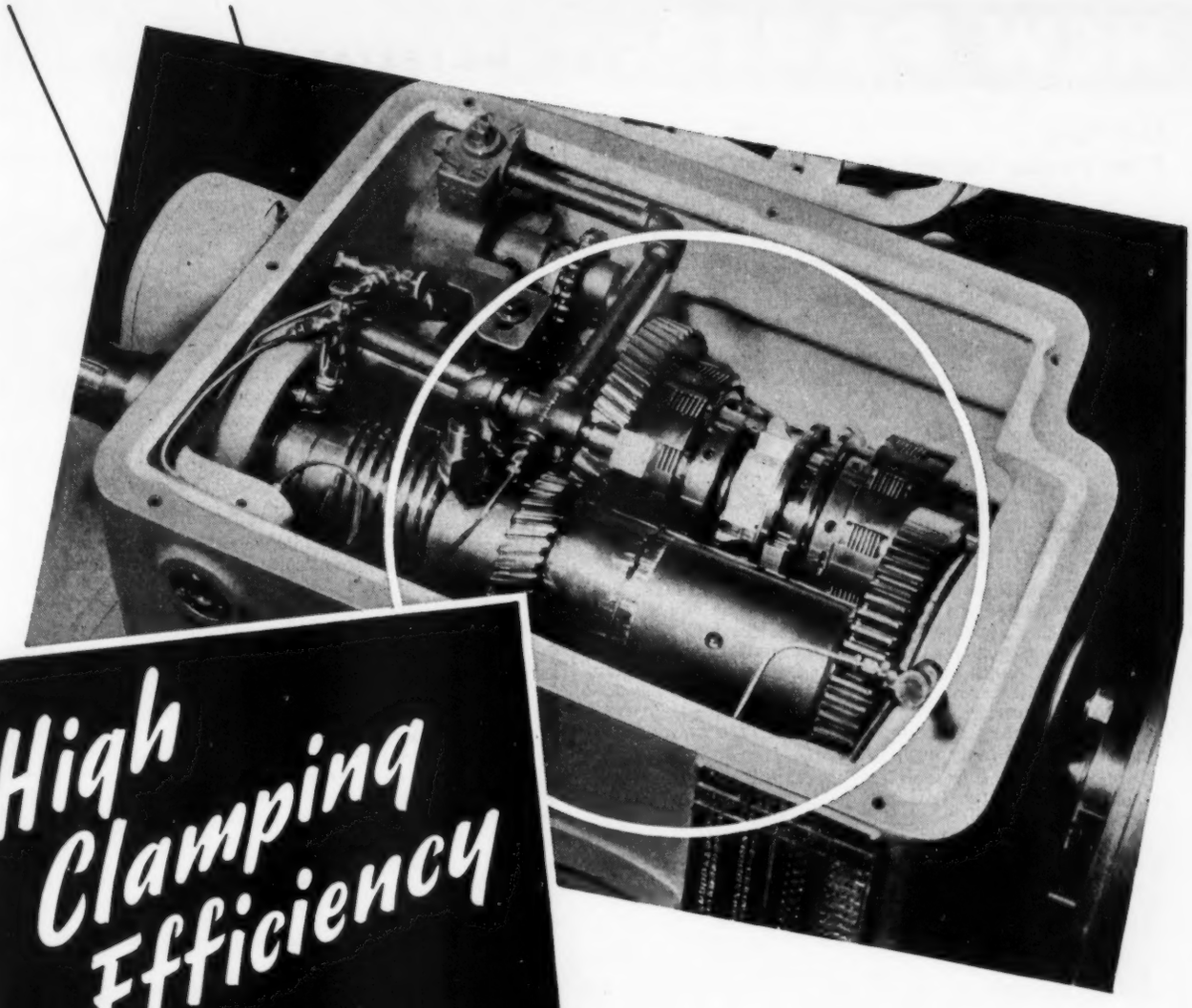
Size: Pressure connection $\frac{7}{16}$-20 NF3 thread per AND10050 and ⅛-in. pipe per AND10053; 1¾-in. diam by 3¼ in. high including connectors

Service: Pressure ranges from 0 to 15 psi to 0 to 1300 psi, operating pressures from 60 to 2500 psi; temperatures from −65 to 200F (with relays) or 250F (without relays); 28v d-c or 115v a-c, 0.25 to 7 amps; withstand 0 to 500 cps vibration to 15g with relays and to 25g without, shock to 30g with relays and to 50g without

Design: Constructions to suit environmental conditions; all welded stainless steel for service in highly corrosive media; miniaturized to save space and weight

Application: For sensing critical pressures under severe environmental conditions such as encountered in aircraft, aircraft engines, rockets, guided missiles, etc.

For more data circle MD 16, Page 197



High Clamping Efficiency

Automatic speed-change Twin Disc Multiple Clutch in the head of a Monarch Tool Company Model Z electrically controlled step shaft contour or form turning automatic lathe.

● Clamping efficiency with comparatively low pressure on the clutch lever, high torque capacity, ease of operation and single point adjustment . . . combine to make Twin Disc Machine Tool Clutches "wear like a bearing and perform like the best friction clutch."

Designed to operate in limited space, the clamping efficiency of Twin Disc MTU and MTS Clutches permits the clutch length to be kept to a minimum. Unaffected by centrifugal action, high speeds of rotation are possible. All parts are machined to close tolerances. Operating parts are heat treated for maximum strength, longer wear-life.

For complete information on Twin Disc Model MTU and MTS Clutches, oil or dry type, single or duplex, write for Bulletin No. 134-A. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).







TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
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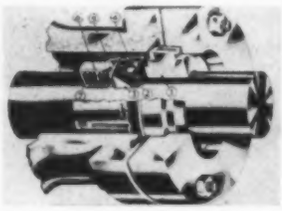


SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

NEW PARTS AND MATERIALS

Shaft Seal 17

Crane Packing Co., 1800 *Cuyler Ave., Chicago* 13, *Ill.*



Designation: Type 9

Style: Mechanical; shaft mount, cartridge, or hydraulically balanced

Size: Specially designed to suit any application

Service: For axial sealing against corrosive media and high temperatures; pressures to 200 psi, higher pressures with hydraulically balanced type; temperatures to 485F

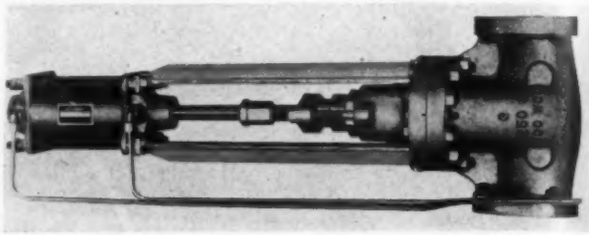
Design: Precision lapped carbon-graphite seal face washer sealed to shaft (or cartridge) by Teflon wedge ring, spring pressure loads Teflon ring and seal faces, positive drive of elements imparted by means of dents in retainer and grooves in washer; retainer set-screwed to shaft; shaft mounted seal rotates, cartridge type stationary; cartridge pressed into stationary housing, mating surface rotates permitting extremely high speeds

Application: For use on rotating shafts or other elements in centrifugal pumps, turbines, positive-displacement pumps, agitators, mixers, etc.

For more data circle MD 17, Page 197

Valve Actuators 19

Ledeen Mfg. Co., 1602 *S. San Pedro St., Los Angeles* 15, *Calif.*



Style: Cylinder and complete control system equipped with mounting brackets and couplings; mountings to suit valves.

Size: Cylinders from 1½ through 12-in. diameter bores.

Service: Air, water, oil, steam or gas operating mediums at pressures from 15 to 750 psi max; actuator capacities from 19 (1½-in. at 15 psi) to 79,520 (12-in. at 750 psi) pounds pull on valve stem.

Design: Power cylinder controlled by 4-way valve and speed-control valves; 4-way valves actuated manually, electrically or by instrument, local or remote; actuators can be equipped with hand pump, spring-return or safety circuit for cases of power failure.

Application: For automatic local or remote on-and-off or positioning control of gate valves, plug valves, dampers, diaphragm valves, butterfly valves, and sluice gates.

For more data circle MD 19, Page 197

Metal Primer 18

Kelite Products Inc., 3401 *Touhey Ave., Chicago* 45, *Ill.*

Designation: Poly-Kote

Form: Fine crystalline film or coating; supplied in concentrated solution

Service: Treating iron, steel and aluminum for corrosion resistance preparatory to painting; applied by immersion or spray, no special dips required; film deposit can be controlled between 50 and 500 milligrams per square foot of surface depending on time of treatment

Properties: Coated, unpainted panel withstands standard 20 per cent salt spray solution (1.152 sp gr) at 96F and atmospheric pressure for 32 hours; coated, painted panels 650 hours; nontoxic; nonflammable; dense; low porosity; has plasticity

Application: For retarding rust and increasing durability of paint on transportation vehicles, farm equipment, household appliances, etc.

For more data circle MD 18, Page 197

Solenoid 20

Practical Electric Co., Dept. CS, 4505 *Oakwood Blvd., Melvindale, Mich.*



Style: Guided armature; open construction, two-screw disassembly

Size: 2⅛-in. wide by 2$\frac{13}{16}$-in. high by 3$\frac{13}{16}$-in. long, ⅛-in. plunger projection

Service: 110, 220 and 440 v, 60 cycle a-c; ⅝-in. max stroke; rated push-pull ranges from 4 to 11.1 lb against gravity at ⅝ to ⅛-in. stroke respectively with 85 per cent voltage; 5.5 to 12 lb at 100 per cent voltage

Design: Fanproof laminations electrohydraulically forge assembled; T-shaped armature for high rating with reduced impact when energized and closed magnetic circuit devoid of air gaps; small coil current required when closed; shockproof backstop; nonmagnetic stainless steel plunger

Application: For controlling operation of magnetic brakes, time-limit switches, relays, circuit breakers, valves, etc.

For more data circle MD 20, Page 197

ADVERTISEMENT

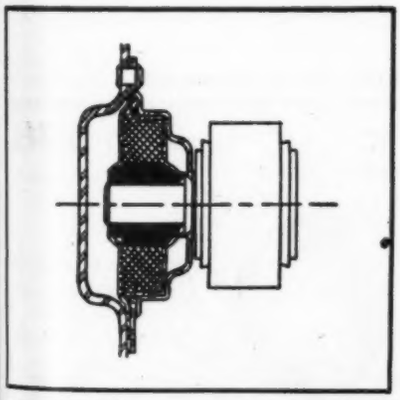
Powder Metallurgy Parts Result in Quiet Operation

Manufacturers of household appliances, business machines and factory equipment have long recognized the importance of quiet operation as a selling tool. Product designers have found economical ways of obtaining this desirable feature through increased use of bearings, gears, cams and other parts produced by powder metallurgy.

These bearings and parts, manufactured under the trade names of "COMPO" (porous bronze) and "POWDIRON" (sintered iron) assure extremely quiet operation because of (1) their accurate dimensions; (2) their method of lubrication.

Accurate Dimensions

"COMPO" and "POWDIRON" bearings and parts are die-formed to their final dimensions within extremely close tolerances. Hence the play of shafts in bearings can be kept to a minimum; gear, cams and similar parts mesh closely and quietly. These advantages are obtained without any need for expensive machining operations to give the required tolerances.



In this application of a self-aligning "COMPO" bearing in an electric fan, accurate dimensioning permits extremely close running clearances, essential for quiet operation.

Method of Lubrication

The lubrication principle used in "COMPO" and "POWDIRON" eliminates any noise-producing metal-to-metal contact between moving parts. When the machine is at rest, oil is stored uniformly throughout the capillary structure of the bearing or part. When the machine starts, oil is instantly fed to the surface from the microscopic pores, thus maintaining a constant oil film.

Recommendations on "COMPO" and "POWDIRON" bearings and parts for specific applications may be obtained from the manufacturer, Bound Brook Oil-Less Bearing Company, Bound Brook, N. J.

"Let's keep this just as quiet as we can!"



EXTREME QUIETNESS is one of the 6* outstanding advantages of "COMPO"® and "POWDIRON"® BEARINGS AND PARTS

Constantly maintained oil film ends noisy metal-to-metal contact. Accurate dimensioning keeps parts working together smoothly and silently. These are the "let's keep it quiet" features of "COMPO" and "POWDIRON" bearings and parts—put them to work in *your* product!

For the latest line-up of stock sizes of "COMPO" bearings, write on your company letterhead. Consult our Engineering Department on special requirements for bearings or parts.

Send for this FREE Booklet



***THE 6 OUTSTANDING ADVANTAGES OF "COMPO" and "POWDIRON" are:**

1. Extreme quietness
2. Efficient self-lubrication
3. Low installation cost
4. Low operating and maintenance cost
5. High load capacity at high speeds
6. Low unit cost

BOUND BROOK

"COMPO" • "POWDIRON" • "BOUND BROOK"

OIL-LESS BEARING COMPANY

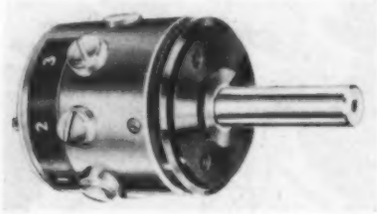
BOUND BROOK, N. J. • BOUND BROOK 9-0441

ESTABLISHED 1883

NEW PARTS AND MATERIALS

Potentiometer 21

G. M. Giannini Co. Inc., 254 W. Colorado St., Pasadena 1, Calif.



Designation: Type 85129 Syncromount

Style: Rotary switch, step type

Size: 1⅛ in. diameter

Service: Linear or functional output; resistance to 100,000 ohms max; torque less than 0.2 oz-in.

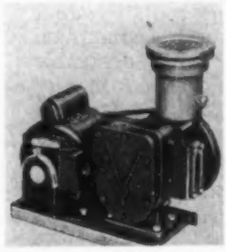
Design: Shaft mounted in ball bearings; shaft runout and concentricity within 0.001-in.; syncro type mount enables potentiometer to be driven direct

Application: For computer, guided missile and aircraft installations where space is at a premium.

For more data circle MD 21, Page 197

Small Vacuum Pump 23

Kinney Mfg. Co., 3529 Washington St., Boston 30, Mass.



Designation: CVM 3153

Style: Mechanical; belt-driven; portable

Size: 14¾ long x 13¼ high x 10¾ inches wide; weight pump 31 lb, complete unit 70 lb; ¼-hp motor drive

Service: Free air displacement 2 cfm; absolute pressures down to 0.1-micron (0.0001-mm Hg)

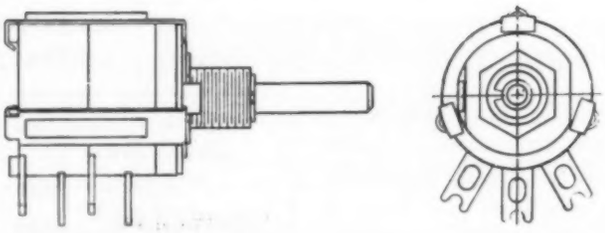
Design: Pump and motor bolted to formed baseplate; oil-sealed pumping system; mechanical shaft seal; pump retains high percentage of volumetric efficiency in low-pressure regions

Application: For production and laboratory machines where high-speed evacuation is necessary—lamp and tube manufacture, forepumping for diffusion pumps, refrigeration, etc.

For more data circle MD 23, Page 197

Variable Resistor 22

Clarostat Mfg. Co. Inc., Dover, N. H.



Designation: Series 48.

Style: Composition element; single or dual; round, flatted or slotted shafts; locking shaft.

Size: Housing ⅝-in. diameter, ½-in. deep single, 13/16-in. deep dual; ¼-in. mounting shoulder with ¼-32 thread; ⅛-in. shaft, ½-in. extension.

Service: Volume control; resistance values 1000 ohms to 2 megohms linear; tapered "Z" 10% resistance at 50% cw rotation and "Reverse Z" 10% at 50% ccw, 5000 ohms to 2 megohms; power rating 0.2 watt.

Design: Mechanical rotation 250 degrees, electrical 220 degrees; two units can be nested together and held by metal straps for dual-control combination; yellow low-loss bakelite housing.

Application: Companion for subminiature tubes in volume-control circuits of electronic assemblies requiring extreme compactness.

For more data circle MD 22, Page 197

Hose Clamp 24

Ideal Corp., Brooklyn, N. Y.



Style: Perforated band with worm screw lock

Size: Accommodates all hose from ½ to 3-in. diameter

Service: Sealing low-pressure hose to fittings or nipples

Design: Screw, screw saddle and perforated band plated to resist corrosion; screw swivels in saddle—band is brought through saddle in snug fit, screw is snapped down and mates with perforations, screw drives along perforated band tightening clamp; clamp released by unscrewing and tipping screw vertically

Application: For making hose connections on aircraft and automotive equipment.

For more data circle MD 24, Page 197

NEW PARTS

Magnesium Brazing Rod 25

All-State Welding Alloys Co. Inc., 273 Ferris Ave., White Plains, N. Y.

Designation: All-State No. 61
Form: Rods in 5-lb standard package with 1-lb package of Brazaloy flux
Size: $\frac{1}{16}$-in. diameter, 18 in. long; $\frac{1}{8}$-in. available only on defense order
Service: Brazing of all types of cast and wrought magnesium except Type AM-403, also joins magnesium sheet; working temp 1090F; applied by Heliarc or corresponding method, can be applied by torch with Brazaloy flux No. 61
Properties: Low-melting point; free-flowing; strength and corrosion-resistance of base metals
Application: For fabricating cast, wrought or rolled magnesium components into assemblies.

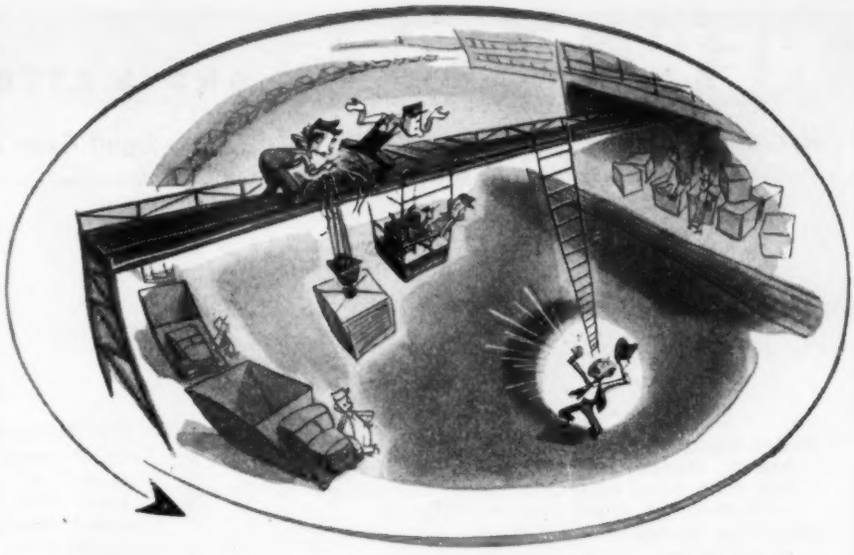
For more data circle MD 25, Page 197

Rubber Compound 26

Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio

Designation: Parker 42
Form: Synthetic rubber molding compound
Service: Nonfuel petroleum products such as lubricants and hydraulic fluids at temperatures from −85 to +275 F; ozone resistance of 0.003 per cent for six hours
Properties: Tensile strength 2000 psi; elongation 300 per cent; Shore A hardness 60±5 degrees; permanent set 3 per cent
Application: For O-rings and other precision molded seals.

For more data circle MD 26, Page 197



Burned-out Motors Waste Manpower!

Men without motors are just about as helpless in a modern factory as a wagon without wheels on a superhighway.

In many plants the failure of a single motor used to drive an overhead crane or a conveyor system can cost thousands of dollars an hour in lost production and wasted man-hours of labor.

The answer is Class H insulation made with Dow Corning Silicones. In a steel mill, for example, a cupola crane hoist motor insulated with the best Class B materials had an average life of only 50 days. Rewind costs alone amounted to $3,634 in three years. That motor, rewound with Class H Insulation at an extra cost of only $79 was still in good condition after 613 days on the hoist and 908 days on the trolley bridge.

And Class H is readily available. Most of the best rewind shops now feature this longer lasting, more reliable class of insulation. Leading motor manufacturers are quoting price and delivery on new Class H machines.

Dow Corning Silicones Mean Business!

MAIL THIS COUPON TODAY!

DOW CORNING CORPORATION, MIDLAND, MICHIGAN
Please send me ☐ More Evidence ☐ List of Class H Rewind Shops ☐ List of Motor Manufacturers Offering New Class H machines. P-6
Name
Company
Street
City Zone State

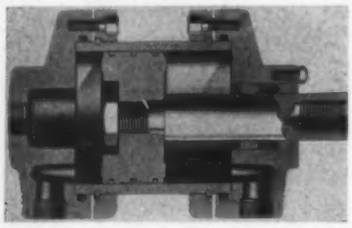
DOW CORNING SILICONES
DOW CORNING CORPORATION

BRANCH OFFICES: ATLANTA • CHICAGO • CLEVELAND • DALLAS • LOS ANGELES NEW YORK • WASHINGTON, D. C. • In CANADA: Fiberglas Canada Ltd., Toronto In GREAT BRITAIN: Midland Silicones Ltd., London.

NEW PARTS AND MATERIALS

Hydraulic Cylinder 27

Rivett Lathe & Grinder Inc., Brighton 35, Boston, Mass.



Style: Snap ring assembly; Double-acting; rotatable covers; standard mountings—clevis, rabbet, centerline, foot, blind flange, trunnion, and rod end flange; cushioned end, blind end or both.

Size: Ten standard bore diameters—2, 2½, 3, 3½, 4, 5, 6, 7, 8, and 10 in.; any stroke up to 96 in.; standard rods or 2:1 oversize.

Service: Hydraulic fluids; three pressure ranges—300 psi, 1500 psi and 3000 psi, max.

Design: Honed drawn seamless steel cylinder, alloy cast iron covers and piston, bronze rod guides; self-adjusting rod packing with axial holes in rod bearing to distribute pressure; piston rings used on piston; O-rings for static seals.

Application: For applying hydraulic power to machine elements.

For more data circle MD 27, Page 197

Small Gear Trains 29

Telechron Inc., Ashland, Mass.



Style: Packaged gear train; spur.

Size: Housing dimensions $1\frac{5}{16}$-in. OD by $1\frac{11}{16}$-in. long; input shaft $\frac{3}{32}$-in. diam with $\frac{5}{16}$-in. extension, output $\frac{1}{8}$-in. diam with $\frac{3}{8}$-in. extension flatted to 0.109-in.

Service: Shaft torque loads to 0.375 lb-in.; standard ratios from 7200:1 to 25:1; other ratios as high as 216,000:1 depending on load.

Design: Capillary lubrication system; hobbed steel gears; stainless steel shafts; shoulders at each end for mounting.

Application: For timers, timing motors, instrument movements, etc., where low-power transmission is desired.

For more data circle MD 29, Page 197

Mining Motors 28

General Electric Co., Small and Medium Motors Div., Schenectady 5, N. Y.



Style: Explosionproof; foot or strap mounting or with face or flange end shield; shunt, compound or series windings

Size: ½ through 60 hp

Service: Bureau of Mines Schedule 2E; 230, 250, 500, and 550 v d-c

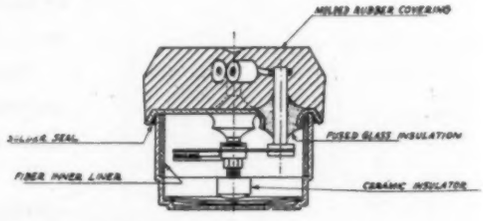
Design: All frames incorporate two-stud brush mechanisms for accessibility; cable gland design permits cable replacement without removal of end shield or working through commutator access openings; Glyptal synthetic resins applied to coils for insulation

Application: Machine drives in explosive atmospheres.

For more data circle MD 28, Page 197

Hermetically Sealed Thermostat 30

Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Mass.



Designation: C 4391.

Style: Snap-action, disk type; hermetically sealed; switch action SPST or SPDT; mounting arrangement to suit.

Size: Approx: $1\frac{5}{16}$ in. max OD. $1\frac{5}{32}$ in. overall height.

Service: Electrical rating 10 amps at 30v d-c and 125v a-c, 8 amps at 250v a-c; differentials between open and close temperatures (factory preset) 15 F and higher to suit.

Design: Terminals brought out through glass seals with rubber bonded over the terminals and leads for complete waterproofing, silicone rubber used for temperature extremes; thermal element in bottom of metal enclosure for proximity to surface or exposed air or liquid; contacts protected by hermetic seal, sealed-in helium or other inert gas where desirable.

Application: For temperature control in industrial or consumer equipment, i.e., automatic refrigerator defrost, or in military equipment such as tanks, aircraft, etc., where shock and vibration are encountered.

For more data circle MD 30, Page 197

NEW PARTS

Bright Protective Finish 31

Allied Research Products Inc., 4004-6 E. Monument St., Baltimore 5, Md.

Designation: Iridite No. 8P (Blu-Brite)

Form: Powdered compound in 100-lb units; Mix A (for 1-10 water dilution), Mix B (1-50)

Service: Bright protective finish for zinc and cadmium plated surfaces, zinc die castings and hot dip galvanize; simple chemical dip, bleach dip optional; min zinc plate thickness 0.0002 and 0.0003-in.; immersion time 5-30 seconds; air blast or centrifuge dry

Properties: Color of coating represents its comparative corrosion resistance—darker color has higher resistance; high chemical polish with higher concentrations, heavier film with low concentrations

Application: For bright, decorative and protective coating of zinc and cadmium surfaces; replacement for chromium or more costly metallic coatings; finishes for zinc replace cadmium where soldering is not a problem.

For more data circle MD 31, Page 197

Sight Glasses 32

Swift Lubricator Co. Inc., Elmira, N. Y.

Form: Pyrex polished plate glass in round, square, rectangular, and odd shapes

Size: Any size that can be fabricated from 24 x 60-in. plate; thicknesses 1/8, 3/16, 1/4, 3/8, 1/2, 5/8, 3/4, and 1-in.

Service: All chemicals except hydrofluoric acid and strong, hot caustic solutions

Properties: Heat-resistant; high thermal shock resistance; does not cloud or pit

Application: For observation windows on ovens, processing tanks, reaction kettles, furnaces, pressure vessels, etc.

For more data circle MD 32, Page 197

Check

R-B-M INDUSTRIAL CONTACTORS NOW!



Underwriters' Approved. 600 Volts AC

SIZE

Non-Reversing

2 to 4 Pole 2-3/4″ w. x 3-5/8″ h. x 3-5/16″ d.
5 to 8 Pole 5-9/16″ w. x 3-5/8″ h. x 3-5/16″ d.

Reversing

2 to 4 Pole 5-9/16″ w. x 3-5/8″ h. x 3-5/16″ d.

Note: 10 and 15 ampere contactors have same mounting and overall dimensions.

ACCESSIBILITY

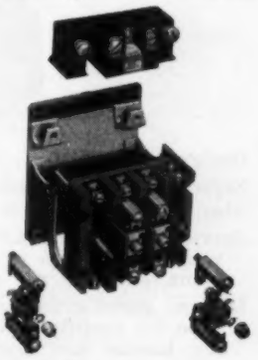
To replace contacts, it is not necessary to disassemble the complete contactor. Just remove the parts comprising the stationary and movable contacts. Contacts can be replaced without disturbing wiring. To change coil, remove magnet frame and coil assembly only. (See illustration below.)

FLEXIBILITY

Using a screw driver only, you can easily change any pole from normally open to normally closed. No special parts required. 10 and 15 ampere parts are interchangeable.

RELIABILITY

Laboratory tests involving millions of operations, plus field service of thousands of R-B-M contactors on door operators, radio transmitters, packaging and weighing machinery, hoists, machine tools and many other industrial applications offer proof of dependable, trouble-free performance.



ADVANCED DESIGN

Melamine Insulation. Molded coil housing. Ilsco solderless connectors. 50/60 cycle magnet coils. Palladium silver contacts. Stainless steel self-contained contact springs.

Where space is a factor, and accessibility a must—use R-B-M industrial contactors. Initial low cost plus dependable performance will save you money. Write for Bulletin 600 and price list on your company letterhead.

Address Dept. B-6

RBM

R-B-M DIVISION
ESSEX WIRE CORP.
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS
FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

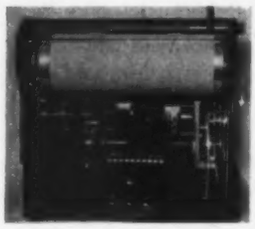
ENGINEERING DEPARTMENT

EQUIPMENT

For additional information on this new equipment, see Page 197

Recorder 33

Baldwin-Lima-Hamilton Corp., Phila. 42, Pa.



Designation: MD-2

Style: Self-contained, portable, autographic, type "X-Y"

Size: Approximately 14 in. long by 10 wide by 13 high; weight 50 lb; 10 in. chart paper, 150 feet long

Service: For stress-strain recording in conjunction with testing machine and extensometer equipment; actuated by Microformers (variable transformer) or Bourdon tubes; full 10 in. scale response of stylus in approximately 6 seconds on full-scale range, 3 seconds on half scale range; full rotation of drum in 20 seconds, 10 seconds with gear change mechanism

Design: Two driving units—for drum rotation and stylus movement; twin amplifiers; two self-balancing bridges include a pair of Microformers—one the recorder and the other, external, electrically connected to it; recording sensitivity of Microformer 0.000015-in., accuracy of recording within 0.2 per cent of scale range

Application: Recording on rectangular co-ordinates of simultaneous relationship between any two variables that can be made to actuate Microformers or in systems where hydrostatic pressure is proportional to load.

For more data circle MD 33, Page 197

Insulation Tester 34

James G. Biddle Co., 1316 Arch St., Philadelphia, Pa.



Designation: CVM

Style: Midget constant voltage type

Size: 5¾ in. high by 5 wide by 7½ long; weight 6½ lb.

Service: Direct readings of insulation resistance; ranges from 0 to 10, 20, and 50 megohms and 10,000 ohms, constant d-c voltages of 100, 250 and 500

Design: Hand crank operated a-c generator with dry type d-c rectifier; plastic case with fold-away carrying handle and crank and flush clamp terminals; fabricoid or leather case

Application: Tests on wiring of aircraft, marine and industrial equipment.

For more data circle MD 34, Page 197

Capacitance Meter 35

MacLeod and Hanopol Inc., 10 Joiner St., Charlestown 29, Mass.



Style: Self-contained, direct reading; relay rack cabinet

Size: Panel 10½ by 19 inches; weight 40 lb; 4-in. indicating scale

Service: Capacitance readings in full scale ranges of 0.1, 1.0, 10 and 100 $\mu\mu f$; measurements made at 500 kilocycles; 60-cycle a-c operated

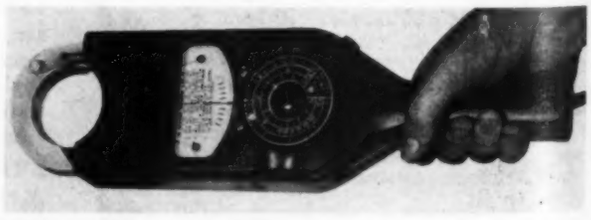
Design: Absolute accuracy better than 95 per cent and reproducibility to less than ½ per cent; standard BNC fittings for connection of two 16-inch test cables

Application: Production and laboratory testing of low capacitance values.

For more data circle MD 35, Page 197

Power Factor Meter 36

General Electric Co., Meter and Instrument Div., Schenectady 5, N. Y.



Designation: Type AK-3

Style: Hook-on type, portable

Size: Effective scale length 13½ in.

Service: Direct power factor reading in balanced three-phase circuits with voltages ranging from 100 to 600 and currents ranging from 15 to 600 amps; frequency range from 50 to 90 cycles

Design: Plastic case with integral handle; direct reading for any case obtained by rotating thumb dial to proper setting; accuracy to within 0.05 PF; voltage breakdown 4000 volts rms

Application: On-the-spot check of power factor in electrical circuits of industrial equipment.

For more data circle MD 36, Page 197

Now-Automatic Lubrication System

SPEEDS...SIMPLIFIES...CUTS COST OF MACHINERY LUBRICATION!

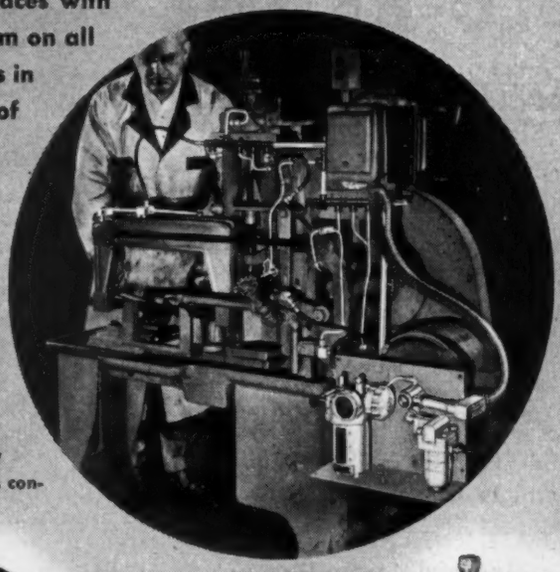
ALEMITE
REG. U.S. PAT. OFF.

OIL-MIST

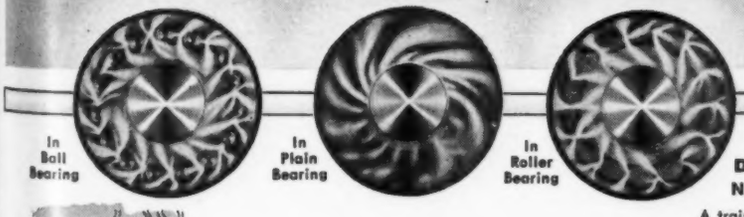
AUTOMATIC LUBRICATION SYSTEM

Unbelievably simple system atomizes oil into mist, distributes it through tubing to bearings. Bathes all bearing surfaces with fresh, clean, cool oil film. Uniformly maintains oil film on all sliding, rubbing, rolling parts regardless of variations in load, temperature or speed. No "peaks and valleys" of lubrication.

Fully automatic—eliminates waste and the uncertainties of the "human element." Extends bearing life as much as 17½ times. Seals bearings against dirt and abrasives. Cuts oil consumption as much as 90%. Greatly reduces the number of oils needed.



Eleven points on this automatic electric saw are served by Oil-Mist. Flexible lines carry lubricant to reciprocating and oscillating parts . . . condensing fittings apply liquid oil to a cam and roller . . . a spray fitting sprays oil on a drive chain, gear and sprocket. The lubricator is controlled automatically by the machine switch.



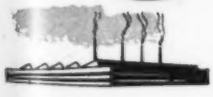
In Ball Bearing

In Plain Bearing

In Roller Bearing

← OIL MIST





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DESK-TOP DEMONSTRATION

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UNIFORM SOCKET DEPTH – True hex shape, clean taperless walls, eliminates socket deformation under high wrenching torque.

CLOSER TOLERANCES – Held to *one-half turn*, plus or minus, on finest ring gages.

ACCURATE THREADS – Checked for lead, pitch – Clean and sharp – Held to standard specifications.

GREATER STRENGTH – *Completely* cold forged of special analysis alloy steel and scientifically heat treated. Also available in metals other than standard alloy.

• *Available from Holo-Krome Authorized Industrial Distributors*

HOLO-KROME

Completely Cold Forged GUARANTEED UNIFORM PERFORMANCE SCREWS *Socket Screw Products*

THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN.

502

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1951

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

78. Speed Reducers

D. O. James Gear Mfg. Co.—56-page illustrated catalog 45-B covers type H worm, helical worm and double worm gear speed reducers. Application and design data given include installation pictures, selection practices, load characteristics, rating tables and specifications.

79. Chain Conveyors

Chain Belt Co.—12-page illustrated bulletin No. 50-35 discusses how to build profits by cutting handling costs. Book stresses importance of careful selection of chain conveyors in instances where they apply and shows numerous examples of chain conveyor application.

80. Pumps & Heat Exchangers

Nukem Products Corp. — 4-page illustrated folder "Nu-Kast Pumps Heat Exchangers and Floor Drains" includes capacity chart and general engineering information on equipment designed for transfer of hot or cold corrosive liquids.

81. Resistance Welder

Progressive Welder Sales Co.—4-page illustrated pictorial 5006 explains application of Magna-Lyte lightweight alloy to portable resistance welding guns. Various types of air or hydraulically operated welding guns are shown and typical applications listed.

82. Screw Type Pumps

Warren Steam Pump Co.—16-page illustrated bulletin No. S-204 revision 1 presents basic construction and design features of antifriction bearing-equipped Quimby screw pumps for handling any nonabrasive liquid or semiliquid at moderate and high pressures. Specifications for a wide range of types and sizes are given.

83. Alloy Steels

Republic Steel Corp. — 16-page illustrated booklet "Republic Alloy Steels and How To Get the Most Out of Them" contains seven case histories showing how company metallurgists have helped customers increase production and cut costs through use of alloy steels.

84. Finishing Accessories

Elgin National Watch Co., Industrial Products Div.—4-page illustrated price list No. 303 lists various Dymo accessories to be used with firm's diamond compound. Included are felt bobs and wheels, abrasive stones, polishing brushes, wood lapping sticks and wheels. They are selected for use on plastic molds, carbide dies, drawing and forming dies and precision parts. Featured is color identification of abrasive stone complementing that used for diamond compound.

85. Organic Coating Strippers

Bathone, Inc.—4-page illustrated booklet describes various strippers for removal of synthetic organic coatings from metals including lacquers, enamels and varnishes. Strippers include those which evaporate fast at room temperature, emulsion type that are mixed with water and brush-on types.

86. Molybdenum Lubricant

Climax Molybdenum Co.—56-page illustrated booklet presents various excerpts from technical papers on use of Moly-sulfide molybdenum disulfide lubricant. Subjects covered include friction of solid films on steel at high sliding velocities, oxidation characteristics of lubricant, and friction and wear of hot-pressed bearing materials containing molybdenum disulfide.

87. Recording Voltmeters

Ariston Co.—28-page illustrated bulletin R1111 describes features of series 500 recording voltmeters and ammeters. Emphasis is placed on recently developed moving-iron measuring mechanism, and complete information is given on ranges, uses and specifications of various models for permanent or portable usage.

88. Kiln Drying & Milling

Lumber Manufacturers, Inc.—4-page illustrated folder explains service offered by company in Specification custom kiln drying of western woods as well as domestic and imported hard and soft woods. Company also does surfacing, resawing, moulding and smooth end trimming to users' requirements.

89. Miniature Speed Changers

Metron Instrument Co.—Purpose, principle of operation and other information are given on zero-backlash miniature speed reducers in 2-page illustrated technical data sheet No. 7. Drives employ preloaded gearing.

90. Sealing Rings

Precision Rubber Products Corp.—6-page illustrated folder is intended to assist in design and selection of O-ring seals for many industrial applications.

91. Plastic Pipe

Johnson Plastic Corp.—8-page illustrated bulletin discusses properties, chemical resistance and applications of Johnsonite plastic pipe. It is furnished in two grades: for lines carrying liquids or gases that are not intended for human consumption; and for lines carrying liquids for human consumption. Pipe is supplied in standard 500-foot coils for ⅛-in. size and 125-ft coils for 3-in. size.

92. Heat Resistant Sight Glasses

Swift Lubricator Co.—Illustrated mailing piece is descriptive of heat resistant sight glasses made from Pyrex polished plate glass and suitable for use on ovens, absorption columns, evaporators, stills and reaction kettles. Glasses can be supplied in rounds, squares, rectangles and odd shapes in ¼, ⅜, ½, ⅝, ¾ and 1-in. thicknesses.

93. Electrical Tapes

Minnesota Mining & Mfg. Co.—8-page illustrated bulletin E-CMB(1101.5)W deals with construction and maintenance applications of Nos. 33, 22, 24 and 27 Scotch brand electrical tapes which feature high elasticity, ample mechanical strength and high dielectric constant.

94. Technical Ceramics

D. M. Steward Mfg. Co.—Two illustrated bulletins "Lavite Technical Ceramics" include table of properties and application information on ferrites. Listed are properties of steatites, semisteatites, cordierite, mullite, zircon, porcelain and fired lava stone.

95. Rotary Switches

S. H. Couch Co.—4-page illustrated bulletin No. 119 depicts and describes type JR multipole rotary switches designed for handling intricate electrical circuits. They are rated 10 amp 125-v ac and 5 amp 125-v dc. Switches are constructed in 2, 5, 10, 15 and 25-section types with each section containing eight contacts equally spaced about perimeter of switch.

96. Indexing Drives

Geneva Machine & Tool Corp.—Illustrated specification sheet tabulates information relative to four, five, six and eight-point Geneva indexing drives as well as geared type for accomplishing almost any indexing function.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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97. Speed Reducer

Dodge Mfg. Corp.—16-page illustrated bulletin A-470A covers Dodge double-reduction torque-arm speed reducer series. Tabular information makes easy selection of right reducer for any installation if horsepower required and speed and size of shaft to be driven are known.

98. Retaining Rings

Waldes Kohinoor, Inc.—Engineering specifications and application data on Truarc retaining rings for taking up end-play are given in 16-page illustrated bulletin No. 6. Bowed and beveled ring types in external and internal styles which compensate for varying manufacturing tolerances and wear are covered and complete dimensions given.

99. Rotary Shaft Seals

Garlock Packing Co.—"Mechanical seals for Rotary Shafts" is title of 16-page illustrated manual which explains design and application of packaged, chevron and O-ring seals. Details of construction, applicable service and sizes are included. Sectional drawings show typical uses.

100. Flexible Shaft Machines

Swarts & White Mfg. Co., Binghamton Flexible Shaft Div.—20-page illustrated catalog describes various Binghamton flexible shaft machines for grinding, sanding, drilling, polishing, buffing and reaming. Table present specifications, capacities and other data. Attachments available for machines are covered, along with special flexible shaft applications.

101. Electric Brakes

Warner Electric Brake & Clutch Co.—Complete instructions for installation, servicing and trouble-shooting on all Warner electric brakes for commercial and coach trailers are contained in illustrated service manual No. 547 E.

102. Miniature Ball Bearings

Miniature Precision Bearings, Inc.—12-page illustrated catalog 51b contains complete specifications on more than 70 different types and sizes of miniature ball bearings. Details of typical applications and diagrams of current installations in various fields are included.

103. Roller Chains & Sprockets

Whitney Chain Co.—Illustrated catalog RS-50 describes full line of roller chains and sprockets which are available from stock. Specifications and engineering reference data are given on American standard roller chains, sprockets and attachments. Dimensional data, strength and weights are supplied on block and cable chain as well as flexible couplings.

104. V-Belt Drives

Boston Woven Hose & Rubber Co.—32-page illustrated catalog BF-50-2-48 deals with Bull Dog fractional horsepower V-belt drives, their selection and application.

105. Accumulators

Greer Hydraulics, Inc.—Illustrated and revised bulletin No. 301 describes construction and operation of hydro-pneumatic accumulators and shows circuits demonstrating how they are used as auxiliary source of power, in closed systems for holding work, as volume compensators and for operating secondary circuits.

106. Packings & Gaskets

Raybestos-Manhattan, Inc., Packing Div.—100-page illustrated loose-leaf catalog P-100 with leatherette cover describes various packings and gaskets, and presents considerable engineering data, selection charts and general information. Raylon products made of Teflon and available as gaskets, rings and irregular shapes are covered.

107. Impedance Bridge

Brown Electro-Measurement Corp.—Details of model 250-C universal impedance bridge for precise measurement of resistance, capacitance and inductance are presented in 4-page illustrated folder 8-15-50. Applications and operation of this instrument are explained.

108. Thread Inserts

Heli-Coil Corp.—16-page illustrated bulletin No. 650-R covers design data on helical-wire thread inserts and their use in protection and repair of tapped holes in aluminum, magnesium, plastics, iron, steel and wood. Tabular data include recommended drill sizes, roughing and finishing-tap specifications and thread gages to be used when installing inserts.

109. Ball Bearings

Marlin-Rockwell Corp.—4-page illustrated folder contains information on M-R-C Synthetic Seal standard dimension ball bearings with removable synthetic rubber seal for keeping out dirt, grit and moisture.

110. Thermostats

Stevens Mfg. Co.—2-page illustrated data sheet presents application and construction information on type S bimetal thermostats made in adjustable and non-adjustable styles. Principle of operation, calibration, response and styles are covered.

111. Overload Release Clutch

Overload Release Clutch Co.—How overload release clutches operate to provide positive safeguard against damage to equipment is explained in 4-page illustrated bulletin "The Watchdog of Machinery." Sectional drawing shows operating principle.

112. Valves

Ross Operating Valve Co.—44-page illustrated catalog describes complete line of standard and modified valves, including straightway, three-way, four-way and four-way five-port units in various sizes of hand, foot, solenoid, pilot, remote control, cam, speed control, shutoff, quick exhaust and miscellaneous valves. Installation details and diagrams are presented with general reference data.

113. Malleable Iron

Malleable Founders Society—4-page illustrated brochure "Malleable Iron Essential to Manufacture Since 1826" shows examples of products made with material and gives reasons for use and general information on industry producing it.

114. Pneumatic Cylinders

James L. Entwistle Co.—12-page illustrated catalog 20A lists models and specifications of nonrotating and noncushioned pneumatic cylinders offered in bore sizes from 1½ to 10 in. Foot, clevis, front-flange and rear-flange mounted single or double-acting models for operating pressures up to 110 psi and stroke lengths to order are featured.

115. Production Facilities

Char-Lynn Co.—16-page illustrated booklet "You and Char-Lynn" describes company's facilities for producing farm hydraulic equipment, as well as die casting, metal production and finishing, production assembly, tool and die making and design engineering.

116. Low Pressure Molding Material

Bolta Products Sales, Inc.—4-page illustrated folder "Presenting Tough, Versatile Boltaron" lists properties, advantages and general specifications of standard stocks of Boltaron high impact low pressure molding material. Light weight and waterproof, it lends itself to forming, sawing, punching, sewing, sanding and printing. Thirteen standard colors are available.

117. Vacuum Calculator

F. J. Stokes Machine Co.—Slide rule type "Vacuum Calculator" is offered free. It permits computations in vacuum research, design and processing work to be performed quickly and accurately by simple operation. Such calculations as needed pump capacity to evacuate given volume to specified vacuum in given time can be handled. Water vapor pressures at various temperatures, capacities of round tanks and other data can be determined.

118. Hose & Fittings

Weatherhead Co.—20-page illustrated catalog H-1451 on reusable steel hose ends and industrial hose describes five types of industrial hose for all pressures, available hose assemblies and hose and fittings. Step-by-step procedures for making up assemblies are depicted.

119. Flexible Shafts & Couplings

Kuprian Mfg. Co.—Typical applications, available fittings, sizes and properties of light duty flexible shafts are detailed in 4-page illustrated bulletin 5194. Also covered are flexible couplings which are particularly suited for control applications in automotive, electronic, aeronautical and industrial equipment.

120. Torquemeter

Baldwin-Lima-Hamilton Corp. — 8-page illustrated bulletin 328 describes Baldwin SR-4 torquemeters which are based on measurement with SR-4 resistance wire strain gages. Dimensional, instrument characteristic and standard graduation tables for instruments ranging from 100 to 20,000 in.-lb are included.

M. D. Numbers					
1	21	41	61	81	101
2	22	42	62	82	102
3	23	43	63	83	103
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5	25	45	65	85	105
6	26	46	66	86	106
7	27	47	67	87	107
8	28	48	68	88	108
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20	40	60	80	100	120

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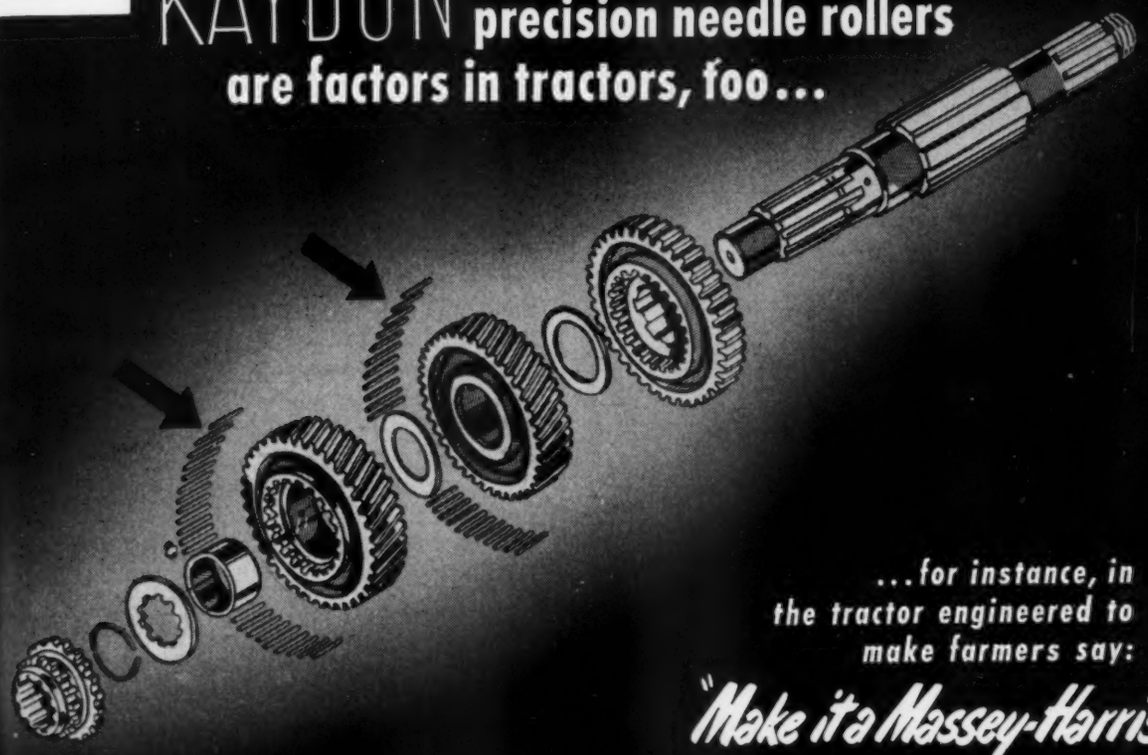




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FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER

KAYDON precision needle rollers are factors in tractors, too...



...for instance, in the tractor engineered to make farmers say:

"Make it a Massey-Harris"

Now Massey-Harris engineers have adopted KAYDON Precision Needle Rollers for the transmission gears of their Model 55 Tractors. Here, as in many other automotive transmissions, universal joints, clutches, steering gears and various precision assemblies in all types of machinery . . . these dependable, economical precision needle rollers are "making good."

Billions of them are being made in standard sizes, 1/16" to 3/16" diameters (tolerance .0002" on diameter), flat or rounded ends. You get the benefit of low cost for highest performance-proved quality, in small or large quantities.

Used between hardened shafts and hardened bores of housings or gears, they eliminate need for bearing races and they provide the most compact high-capacity anti-friction bearing possible. They require no more space than so-called plain or "solid bearings." • Tell us what sizes and quantities you might use. It pays to "contact KAYDON of Muskegon."



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PRECISION BALL AND ROLLER BEARINGS



HOW TO REDUCE
YOUR MOTOR CONTROL PROBLEM
TO ONE QUESTION—WHERE?

"Building-block" units permit grouping all motor controls at one point

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Prefabricated MULTITROL units (each a complete control for one motor) fit into standard framework in any arrangement to suit the space. Units can be added, subtracted, interchanged, or relocated.

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Investigate MULTITROL. Wide choice of starter types, combined with externally-operated thermal circuit breakers. Write for Bulletin 4410. WARD LEONARD ELECTRIC CO., 58 South Street, Mount Vernon, N.Y. Offices in principal cities of U. S. and Canada.

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WARD LEONARD
ELECTRIC COMPANY
Result-Engineered Controls Since 1892
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

MEN OF MACHINES



Fred K. Powell Jr.

Formerly director of engineering, **Fred K. Powell Jr.** has been named vice president in charge of engineering of American Machine and Foundry Co. Mr. Powell first became associated with American Machine and Foundry Co. in 1947, after eight years with the General Electric Co. He joined General Electric upon his graduation from the University of Missouri in February, 1939, as a bachelor of science in mechanical engineering. He was named director of AMF engineering in September, 1950. In 1946, Mr. Powell received the Charles Coffin Award for his work in development of magnetic mine sweeping equipment.

•



Edgar H. Cummings

Edgar H. Cummings has assumed the duties of chief engineer of the Cleveland Chain & Manufacturing Co. and Round Associate Chain Companies. The Round Companies operate nine plants and warehouses in the United States devoted to the manufacture and distribution of welded and weldless chain, as well as a line of hand chain and electric hoists and other materials handling equipment. In his new position Mr. Cummings will have charge of plant, production, and design engineering for the system. Previous to his new appointment, he was assistant chief engineer for American Monorail Co. and before that was a research engineer for the Republic Steel Corp. At present chairman of the Cleveland section of the ASME, Mr. Cum

mings attended Case Institute of Technology and John Huntington Polytechnic Institute.

♦



Herman A. Bottenhorn

Herman A. Bottenhorn has been appointed chief engineer of Loewy Rolling Mill Division, Hydropress Inc., New York. Mr. Bottenhorn is a graduate mechanical engineer and is a specialist in the design, development and manufacture of rolling mills for the ferrous and nonferrous industries. He has held similar positions with leading rolling mill concerns and has been a collaborator of Erwin Loewy, president of Loewy-Hydropress, for more than 30 years.

♦

An employee of the Cleveland Automatic Machine Co. for 33 years and chief engineer since 1944, **A. F. Jelinek** has been named a director of the company.

♦

David B. Steinman, who holds three degrees from Columbia University, has received the Egleston Medal for 1951 from the Engineering School Alumni Association of the University. Considered one of the world's outstanding bridge engineers, Mr. Steinman is also known as the father of legislation requiring licensing of professional engineers, is the inventor of several important techniques in bridge design and construction, and is the author of many treatises, papers and articles.

♦

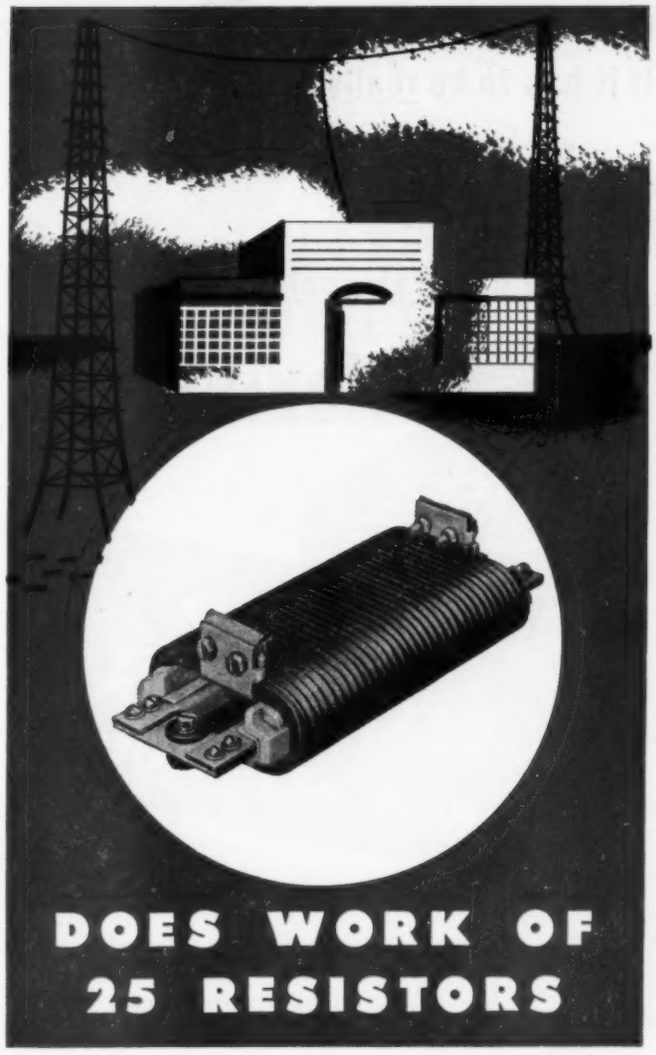
John Delmonte, 719 West Broadway, Glendale 4, Calif., has resigned from Plastics Industries Technical Institute and West Coast University in order to devote full time to research and consulting activities in plastics. Mr. Delmonte has written many articles on plastics for MACHINE DESIGN and is the author of *Plastics in Engineering*, one of the books in the MACHINE DESIGN series.

♦

On leave of absence while serving with the U. S. Department of Agriculture, **John I. Thompson** has returned to the positions of president and chief engineer of John I. Thompson & Co., Washington, D. C., engineers.

♦

Link-Belt Co. has announced the appointment of **Robert W. Suman** as chief engineer of its Philadelphia plant. He has been chief engineer for power transmission products since 1946 and is now assuming the added responsibility of materials handling equipment engineering. Two new appointments were also made



saves work—and cost—of hooking them up

It used to take 25 conventional resistors, 11¾ x 1⅛ in., spaced on 2½ in. centers, to keep the power company happy.

Ward Leonard worked out the problem with a *single* Edgeohm resistor, 19 in. long—saving all that space, weight, mounting and wiring.

Here's the application: a 40-kw radio transmitter, operating from a 50 kva transformer, made by a large transmitter manufacturer. Problem: limiting inrush current to avoid a severe voltage drop (objected to by the power company) and a strain on the line contactor.

This single Edgeohm unit is rated for continuous duty at 2200 watts, and when used for a 15-second interval, will dissipate 6400 watts!

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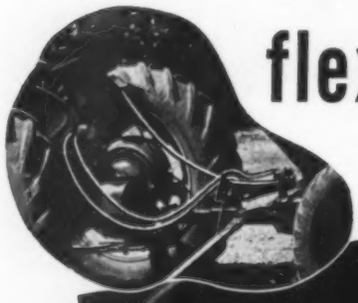
If it has to be really

oilproof

and have fatigueless

flexibility...

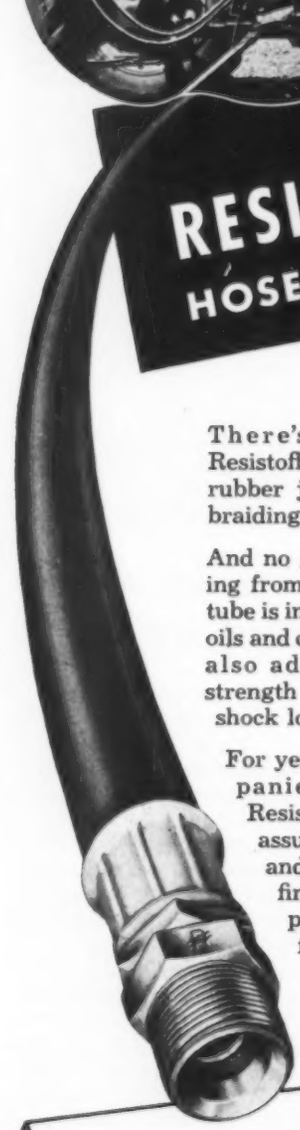




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And no gumming, eroding or swelling from oil either. For the compar tube is impervious to water-insoluble oils and compounds. The compar tube also adds more than necessary strength for medium pressures and shock loads in hydraulic systems.

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recently at the company's Pershing Road plant in Chicago. **Ralph W. Rausch** was appointed consulting engineer, and **Joseph J. Richard**, heretofore executive assistant chief engineer, was named to succeed Mr. Rausch as chief engineer.

•

Two new appointments were announced recently in the Turbine divisions of the General Electric Co. **W. E. Blowney** has been appointed divisions engineer of the company's Steam Turbine, Generator and Gear Engineering division at Lynn, Mass., and **L. B. Wales** has been named division engineer of the Auxiliary Turbine Engineering division at Fitchburg, Mass.

•

Ralph H. LeBow has joined The Parker Appliance Co. as staff engineer for aircraft fuel system components. Upon graduation from Massachusetts Institute of Technology in 1938, Mr. LeBow joined Lawrance Aeronautical Corp. Following three years of naval service in the Bureau of Ships, he returned to the field of aviation, joining the Power Plant Laboratory of the Air Materiel Command at Wright Field. Mr. LeBow assisted as USAF technical adviser in the first non-stop jet aircraft Atlantic crossing in September, 1950, a flight accomplished by several in-air refuelings utilizing a new method.

•

Two new appointments have been announced by Harnischfeger Corp., Milwaukee. **Joseph G. Surmacz** has been named to the newly created position of chief industrial engineer, and **David A. Drewery** has been appointed plant industrial engineer.

•

The Scaife Co. of Oakmont, Pa., has announced the appointment of **Allison L. Bayles** as vice president of engineering. He will be in charge of all phases of plant engineering, as well as product design and engineering. Mr. Bayles formerly was associated with C. H. Wheeler Manufacturing Co. and American Engineering Co., Philadelphia.

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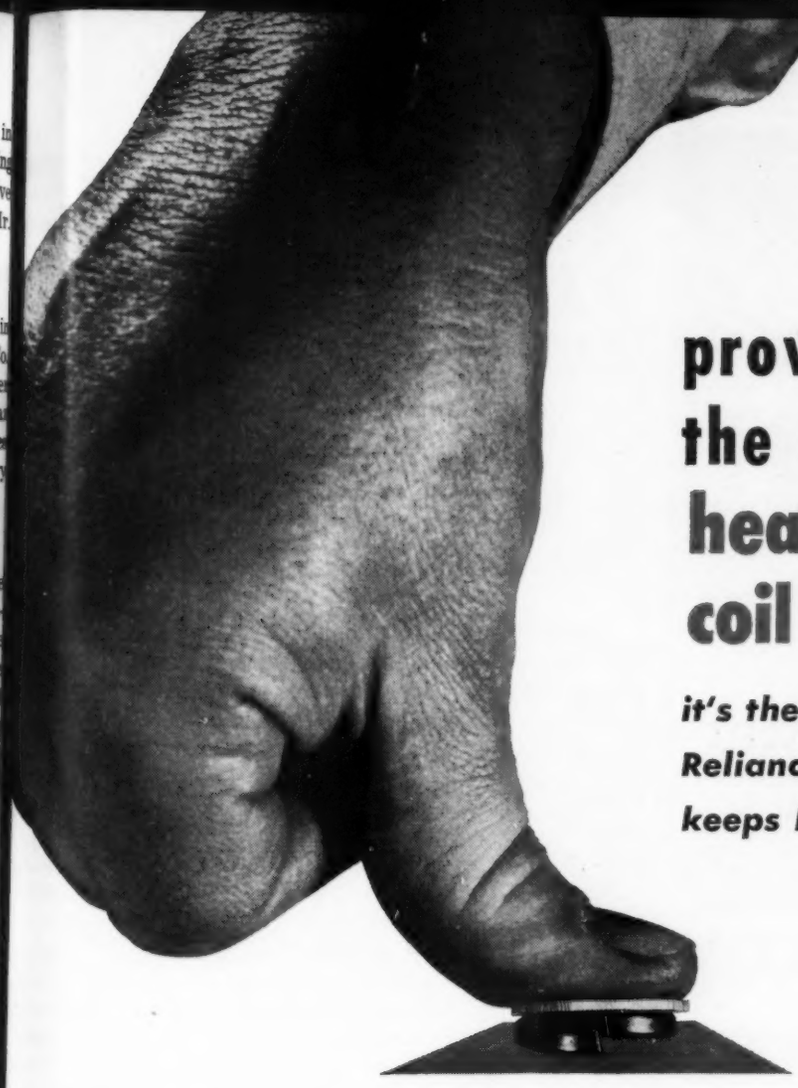
W. F. Tuttle has been appointed chief engineer of Armco Steel Corp., Middletown, O., replacing **E. N. Millan.** Mr. Millan asked to be relieved of his duties as active executive head of the engineering division but will continue with the company in a consulting and advisory capacity on engineering problems.

•

Magnethermic Corp., Youngstown, recently appointed **B. C. McArthur** as chief engineer. For the last seven years he has been with Aluminum Co. of America, Cleveland, in charge of induction heating development and application.

•

John S. French has been appointed assistant director of the Office of Defense Products, Ford Motor Co., Dearborn, Mich., succeeding **Harold R. Foss**, who was named assistant director of manufacturing engineering. Mr. Foss was a member of the manufacturing engineering staff before being transferred to the defense products office last fall.



prove to yourself the advantages of a heat treated helical coil washer...

it's the natural mechanical action of Reliance Spring Lock Washers that keeps bolted assemblies .....

TIGHTER LONGER



Faster Assemblies, too

You can have Reliance Spring Lock Washers of the correct type and size, pre-assembled on the bolts or screws you use, saving the time required to assemble them. They're called Eaton Springtites. Write for bulletin S-49.



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Reliance Snap Rings fit into shallow grooves in shafts or bores, forming strong, long-wearing external or internal shoulders without extensive, costly machining or waste of metal. Write for bulletin.



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- no other fastening device provides the dependable, enduring bolt tightness you get by using Reliance Spring Lock Washers.
- keep this test in mind when you specify or order fastening devices.

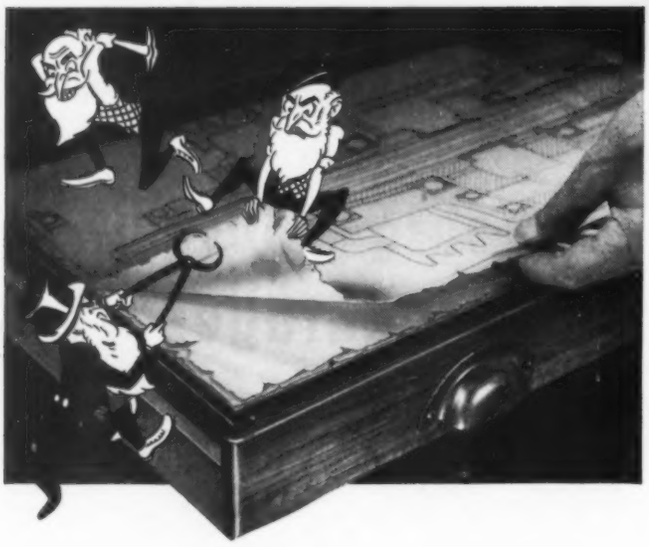
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THE ENGINEER'S Library

The Behavior of Engineering Metals

By the late H. W. Gillett, chief technical adviser, Battelle Memorial Institute; published by John Wiley and Sons, Inc., New York; 395 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$6.50 postpaid.*

To explain the performance of engineering metals—not the reasons or theory of behavior—is the chief objective of this book. Thus, it is written for those who are not metallurgists but who participate in the selection of metals and alloys for engineering use. In keeping with this purpose, the first six chapters of the book deal with basic concepts in minimum technical language. Portions of this extended introduction appeared as articles in MACHINE DESIGN for March and May, 1951. The next nine chapters outline the behavior of each of the principal commercial metals and alloys, ferrous and nonferrous, including less-common alloys such as those of titanium, zirconium, silver, gold, platinum, tantalum, and molybdenum. The next eight chapters discuss various influences on material behavior and selection, such as: effect of hydrogen; machinability; inhomogenous, clad, and coated metals; metal films and surfaces; powder metallurgy; bearing metals; wear and corrosion; and extreme-temperature service. In the final chapter, various economic or strategic factors in material selection are briefly discussed. For those who wish to investigate metals and alloys in greater detail, a helpful list of reference sources is included as an appendix.

□ □ □

Gas Turbines

By Harry A. Sorensen, professor of mechanical engineering, State College of Washington; published by the Ronald Press Co., New York; 460 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$6.50 postpaid.*

Although written as a textbook suitable for advanced college courses, this book contains a number of features which will appeal to practicing engineers. The author has drawn upon his experiences with Pratt and Whitney on jet engine and gas turbine design to produce a work which combines theory with a practical approach. Knowledge of the elements of engineering thermodynamics is a prerequisite to certain portions of the discussion, but for the benefit of engineers who may be slightly rusty in this field a review chapter on basic principles is included.

The book is organized into twelve chapters by topic or function rather than by application. Thus,

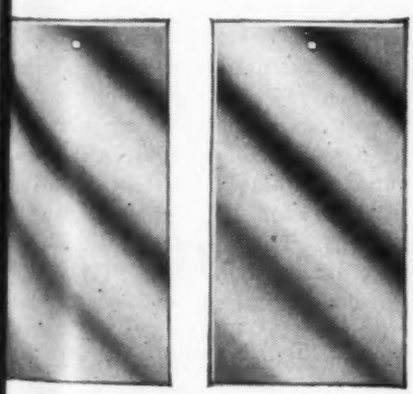
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Clear Coatings for Zinc and Steel Stand 800 hours' Salt Spray

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These tests demonstrate that DULAC Clear Universal Lacquer #462 and CODUR Clear Synthetic Y743 provide completely satisfactory protection on zinc, zinc plated steel and steel. Even after the unusually severe tests to which these finishes were subjected, there was no indication whatever either of failure of the coating or of discoloration of the zinc.

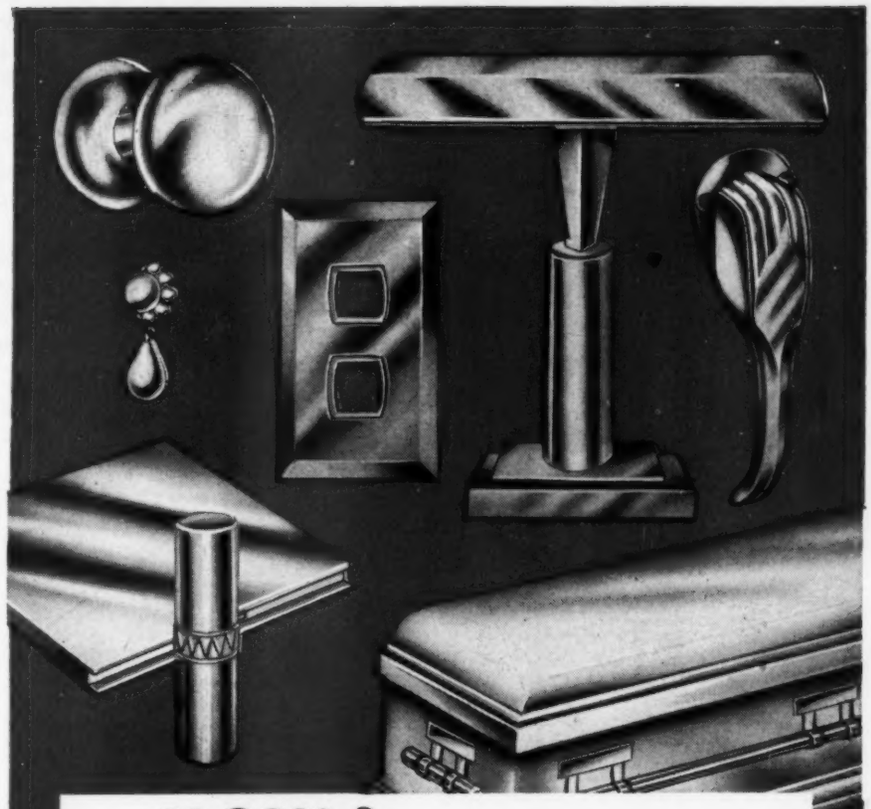


(Left) A zinc-plated steel panel newly coated with DULAC #462. (Right) A similar panel after 800 hours' exposure to salt spray, showing no evidence of attack on the finish.

Adaptability to Drying Schedules

While both finishes give the same performance, DULAC #462 is an air-drying coating, while CODUR Y743 is a baking type. This permits choice of the correct finish to fit into the drying schedules of a particular finishing room.

Technical Data Bulletin #110 on clear finishes is available from Maas & Waldstein Co., 430 Riverside Avenue, Newark 4, N. J. On request, M & W Technical Service Engineers will discuss specific problems.



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● Don't let critical metals put a *needless* crimp in your production!

Take zinc or steel—apply a coating of one of the new PLATELUSTRE finishes. You wind up with products and parts that look so much like copper, brass and bronze that *the eye can scarcely tell the difference!*

Whether you have been using now unavailable copper and its alloys for *making* products or for *plating* products, you will find these new M & W finishes *equally* effective in keeping your plant running. There are types for air-drying and baking schedules — pick the one that best fits *your* production requirements.

Let an M & W Technical Service Engineer show you—*right in your own plant*—how easy these PLATELUSTRE coatings are to use, and what striking effects they produce. Or, if you prefer, write for free literature.

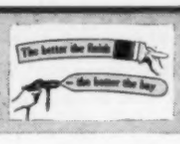
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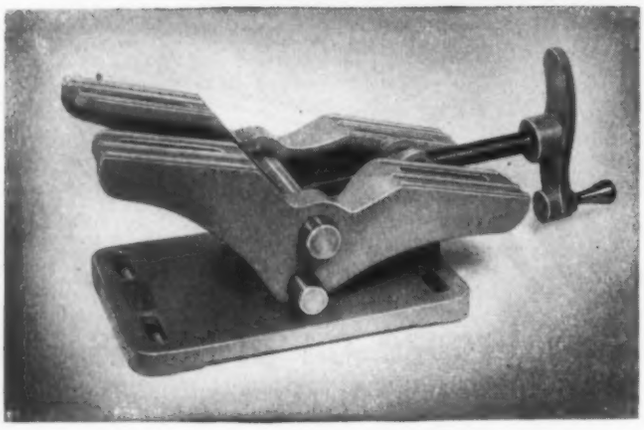
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In design, it is adjustable in both width and length to accommodate all sizes and types of motors up to ¾ HP.

In performance, the Lovejoy Tilting Motor Base offers flexibility of production. When used with a variable speed pulley, speed adjustments may be made while the motor is in operation, merely by turning the handle screw adjustment. It maintains proper belt tension at all times.

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typical chapter headings are: simple open-cycle gas turbines; the axial-flow compressor; centrifugal and positive-displacement compressors; axial-flow turbines; combustion systems; structural design; and plant performance. Although to date there is more experience with aircraft applications than with other types of powerplant, the book treats the gas turbine powerplant as a basic type which can, through modifications in design and construction, be applied to many classes of service. The appendix contains condensed tables of thermodynamic properties of air and products of combustion, and the book concludes with a series of numerical problems.

□ □ □

The Practice of Lubrication

Revised fourth edition, by T. C. Thomsen; published by McGraw-Hill Book Co., New York, N. Y.; 617 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$8.00 postpaid.*

Carrying the subtitle *An Engineering Treatise on the Origin, Nature and Testing of Lubricants, Their Selection, Application and Use,* this book by a Danish author has for many years been a standard reference work in its field. This new edition, the first since 1937, includes much information on developments arising out of wartime experiences. Advances in lubricant technology, such as synthetics and the use of additives, are covered. There is also discussion of the problems arising from higher speeds, higher pressures, and extremes of heat and cold.

Six preliminary chapters are devoted to lubricants and their testing. These are followed by a series of chapters on the fundamentals of lubrication of the various types of bearings such as journal, thrust, and ball and roller bearings. The remaining portion of the book, comprising almost two-thirds of the total number of pages, is devoted to chapters on the lubrication of specific types of machines such as turbines, engines, rolling stock, machine tools, and textile machinery. The chapter on gasoline engines contains a brief discussion of aircraft engines, including jet engines and aircraft accessories, which seems somewhat inadequate in the light of the known difficulties experienced in lubricating this type of equipment. The book concludes with three chapters on oil recovery, purification, storage and distribution, and on cutting lubricants and coolants.

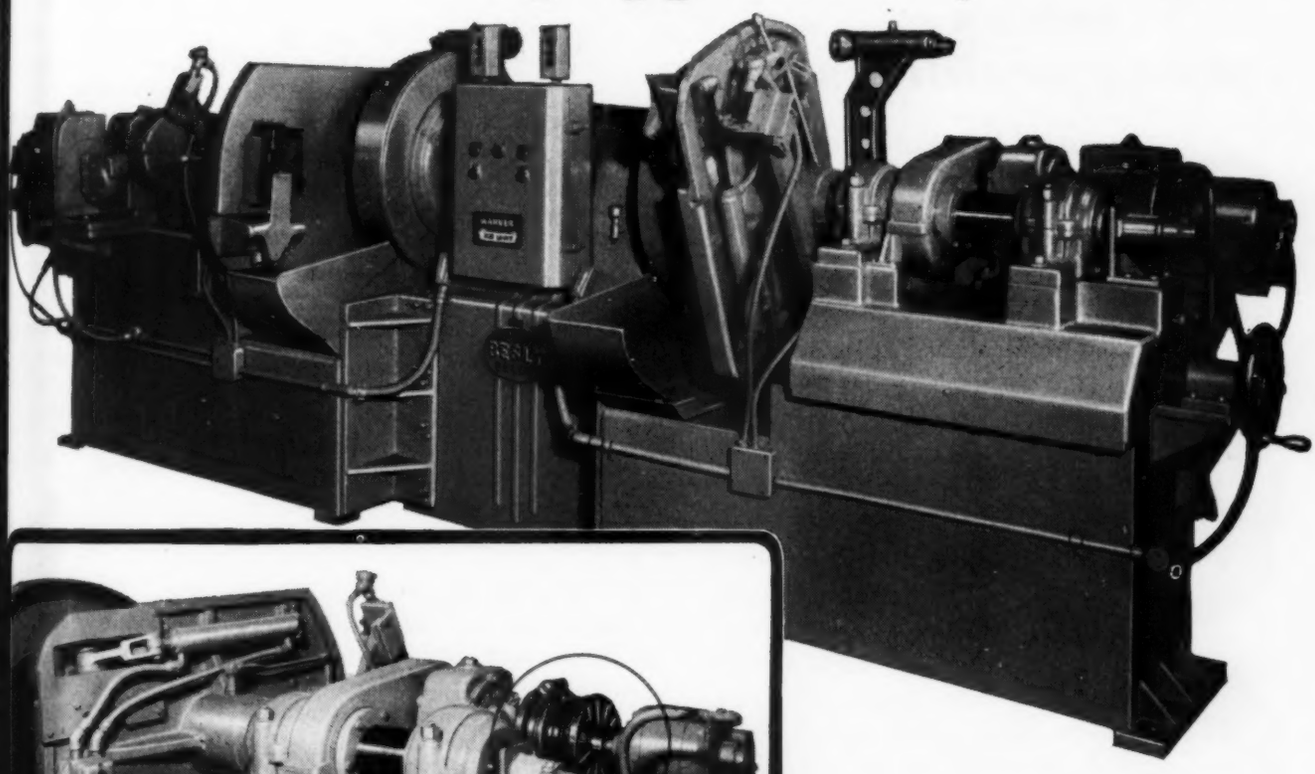
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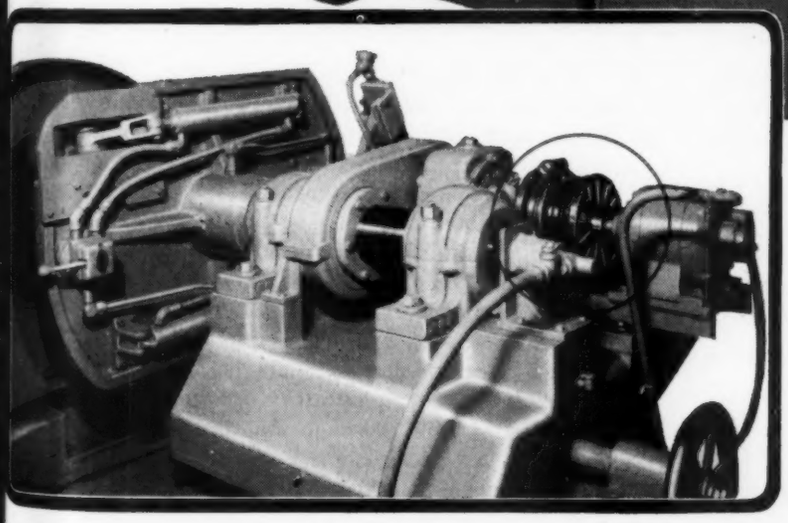
Dimensional Analysis and Theory of Models

By Henry L. Langhaar, professor of theoretical and applied mechanics, University of Illinois; published by John Wiley and Sons Inc., New York; 166 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$4.00 postpaid.*

Practical uses of dimensional analysis range from

FREE HAND GRINDING ELIMINATED on heavy journal bearings with WARNER ICB equipped Besly Grinder





Full view of Besly special two-station grinder for facing off bronze journal bearings. Machine incorporates two Warner ICB combination electric clutch and brake units. (See close-up). Machine completes three bearings per minute, eliminates human error of hand grinding, assures uniformity. ICB units start, stop and position work pieces at each work-holding station.

WARNER ICB units offer a wide variety of design possibilities in the control and operation of nearly all types of machinery. Simple in construction, they occupy little space. Operated electrically, they provide instant, smooth response. Already being used on many different kinds of machinery to simplify control, eliminate complicated mechanical drives, increase production, provide greater safety and reduce maintenance, WARNER ICB units are available in several sizes, as single clutch or brake units, or in combination. Write today for complete information. Our engineers will consult with you, at no obligation. WARNER ELECTRIC BRAKE & CLUTCH CO., Beloit, Wisconsin., Dept. MD.

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ICB UNIT

WARNER ICB Units are manufactured by Warner Electric Brake Mfg. Co. — pioneers in the field of electric brake design and application since 1927.



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solves many problems

caused by sliding or rotating parts which are difficult or impossible to lubricate











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the simple to the complex. At one end of the scale is the application to working formulas to find what numerical adjustments must be made if the units of measurement are changed. At the other end are the derivations of formulas and "laws" which enormously simplify the determination of experimental constants and coefficients by pointing the way to systematic testing programs.

Ten chapters cover: Nature and use of dimensions; principles and illustrations of dimensional analysis; systematic calculation of dimensionless products; algebraic theory of dimensional analysis; similarity and model testing; dimensional analysis applied to problems of stress and strain; some applications of dimensional analysis in fluid mechanics; dimensional analysis applied to the theory of heat; dimensional treatment of problems of electromagnetic theory; and differential equations and similarity.

Although the treatment of fundamental principles is systematic and thorough, that part of the book that would be needed by an engineer in solving practical problems requires for its understanding only basic algebra and an appreciation of the concept of a function. Use of matrices is presented in such a manner that numerical procedures can be reduced to simple routine, eliminating cut-and-try methods and arbitrariness in results. Numerical examples are worked out in the text and additional problems given at the ends of the chapters; answers to the problems are provided at the end of the book.

New Standards

Code for Pressure Piping ASA B31.1-1951: Sponsored by the American Society of Mechanical Engineers, this pressure piping standard specifies minimum safety requirements for: (1) selection of suitable materials and reference to standard specifications by which they may be secured; (2) designation of proper dimensional standards for the elements comprising piping systems; (3) design of the component parts as well as the assembled unit including necessary supports; (4) erection of these systems; and (5) test of the elements before erection and of the completed systems after erection.

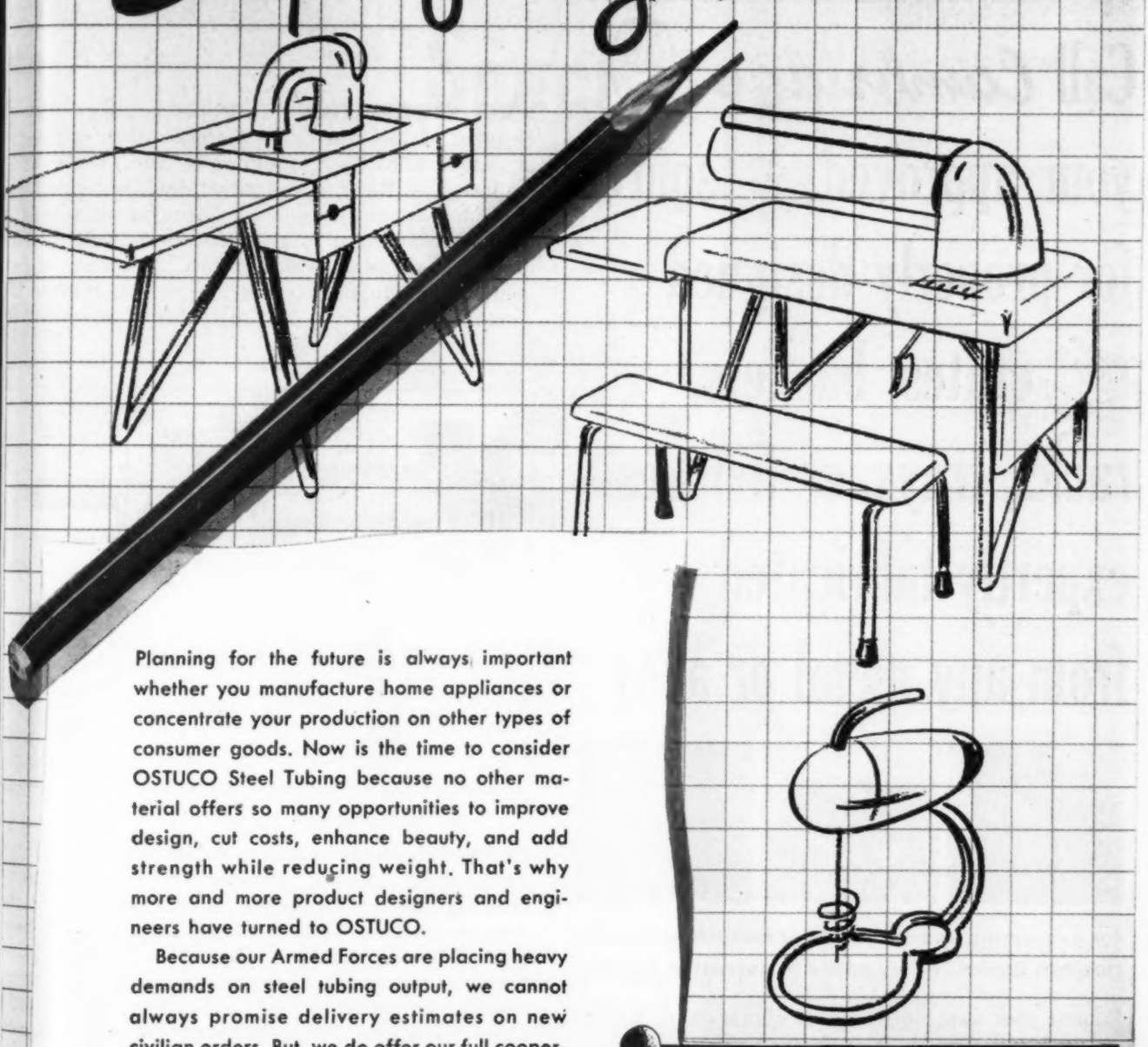
Copies of this 100-page standard may be obtained from the American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., at $3.50 per copy.

Proposed Standards: The American Society of Mechanical Engineers recently announced distribution of the following proposed American Standards:

1. ASA B5—Mounting Dimensions of Lubricating and Coolant Pumps for Machine Tools
2. ASA B16—Nonmetallic Gaskets for Pipe Flanges
3. ASA B32.1—Preferred Thicknesses for Uncoated Thin Flat Metals

Copies of tentative drafts of these standards may be obtained by writing to the American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y. Comments on the proposed standards are invited by the respective committees.

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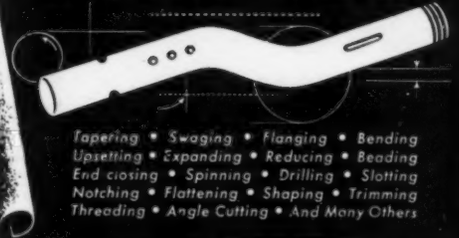
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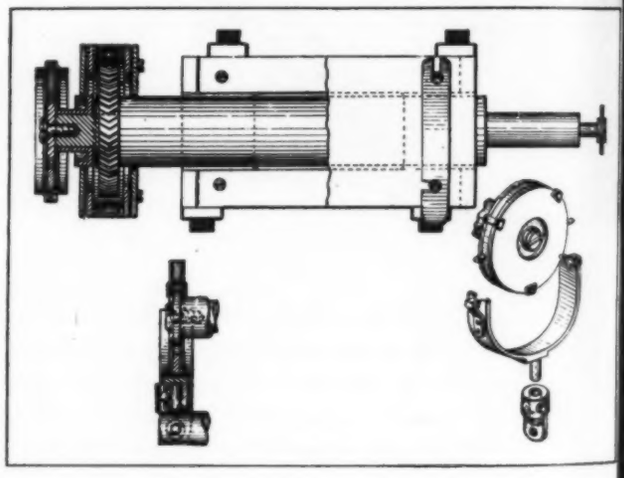
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NOTEWORTHY Patents

AIR LUBRICATION of spindle bearings without clogging of the bearing by foreign matter is covered in patent 2,535,454. Assigned to The Sperry Corp. by Joseph A. Rawlins, the patent describes thrust and journal bearings for spindles operating at speeds to 50,000 rpm, such as in grinding wheels, with bearing clearances as small as 0.0001-inch. Tendency of conventional air-lubricated bearings to bind after becoming clogged with dust particles is overcome by



joining the journal bearing blocks with spring clips. This spring mounting permits sufficient radial movement of the bearing blocks to allow passage of any foreign particles without forcing them into the bearing surfaces. Similarly, the two stationary plates forming the thrust faces of the disk type thrust bearing are pivotally held by spring clips to make them self-aligning in relation to the disk. Impurities drawn in between disk and thrust faces can pass through without jamming the thrust bearing.

ROLLING, rather than the conventional linear movement, of valves in pressure regulators requires a lower operating force and therefore permits use of smaller and more compact diaphragms. Such a device is covered in patent 2,517,534, assigned to The Weatherhead Co. by Louis B. Courtot. The valve itself, a rubber or plastic cylinder formed around a metal sleeve, is mounted on a cam or offset section of the valve operating rod. A diaphragm, sensitive to valve outlet pressure, is connected to the valve rod through a rack and pinion arrangement to convert linear diaphragm movement to the rolling valve move-

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As with any other new material, habitual specifications should often be reviewed when considering Oilite finished machine parts. To illustrate, designers using cold rolled steel, may automatically apply the strength specifications of that material. The engineer, however, knows that strength as low as 40% of steel is satisfactory.

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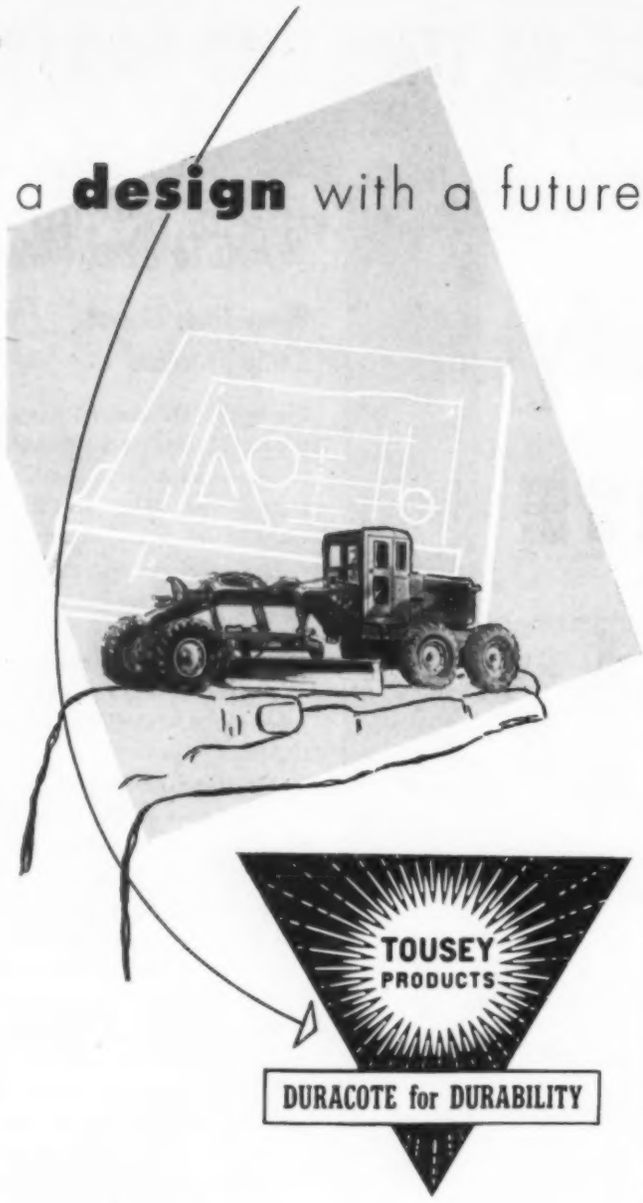
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President

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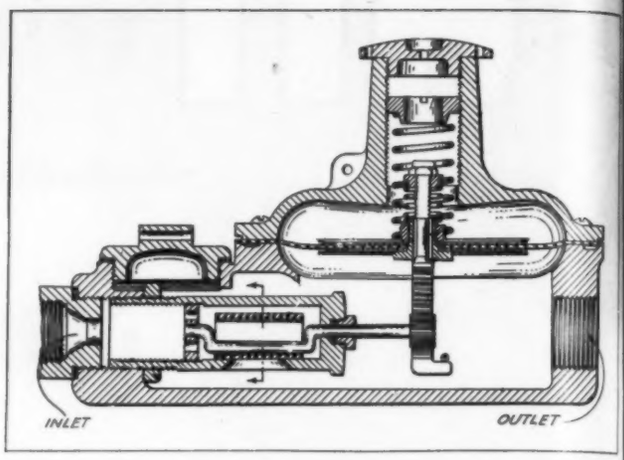


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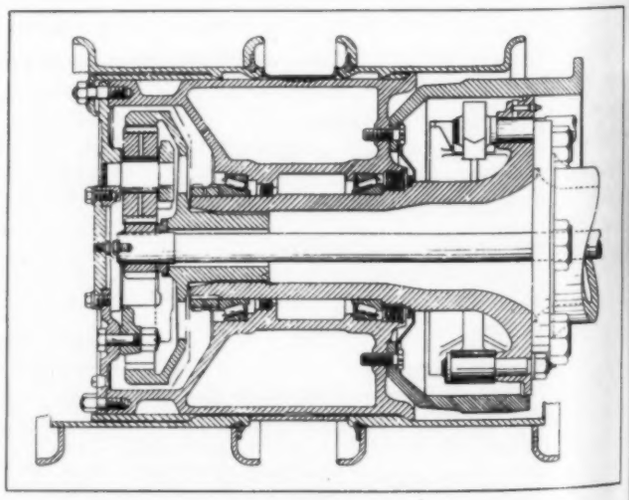
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ment. Displacement of the diaphragm in response to outlet pressure variations rotates the valve rod and moves the cylindrical valve to either cover or uncover the inlet slot. This valve construction requires only a small operating torque. Also, inlet pressure does not tend to open or close the valve. The only unbalanced pressure is that exerted against the end of the valve rod—an axial force which has no effect on valve position.

FLOATING DRIVESHAFT employed in a heavy-duty vehicle wheel drive does not require radial bearings in the planetary gear drive mechanism. Patent 2,543,811, assigned to The Euclid Road Machinery Co. by Virgil L. Snow and Walter F. Double, describes a mechanism contained within the wheel drum, which is driven by a floating driveshaft carrying the sun gear. Planetary pinion shafts are mounted on the wheel cover plate, with the ring gear splined to the station-



ary axle housing through a spider. Ring and sun gears (and consequently the floating end of the drive shaft) are kept in correct radial position only by their contact with the pinions which are, of course, confined radially by the cover plate on which they are mounted. Since any end thrust is absorbed by a pair of but-



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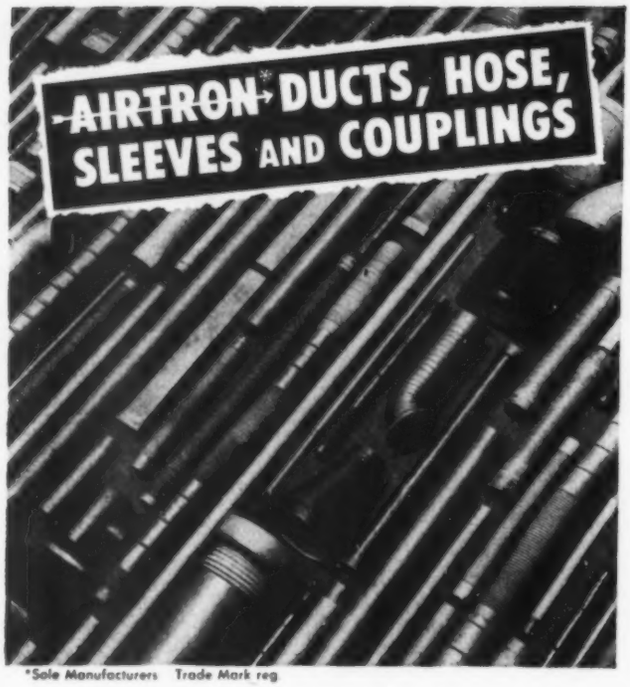
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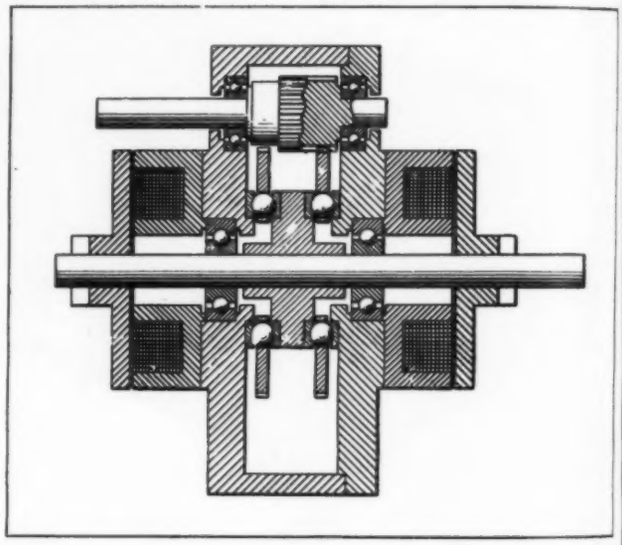


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tons on the cover plate and the driveshaft, the planetary mechanism can float freely without use of radial bearings.

REVERSIBLE TRANSMISSION, primarily for servomotors in remote control systems, uses balls or rollers as motion transferring elements to obtain short reversal time. A constantly rotating input shaft drives two disks in opposite directions through mating gears. Holes in the disks carry balls between races on the transmission housing and on a hub keyed to the output shaft. Energizing one of two magnetic cores



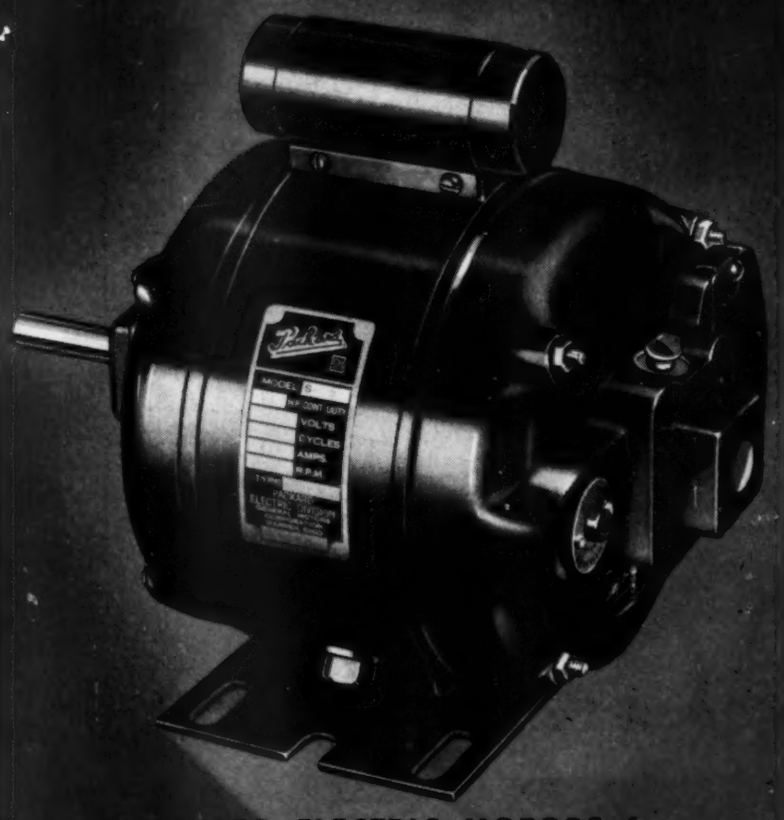
causes the output shaft to be moved axially a short distance, increasing friction between the hub and balls in one of the disks and decreasing the friction between the hub and balls in the other disk. The output shaft then rotates with the disk toward which the hub was moved. Since axial movement of the output shaft is generally less than 0.01-inch for full forward to reverse shifting (depending on axial play in the shaft bearings used), the reversing time can be made extremely short. The patent, No. 2,524,905, has been granted to Carl-Erik Granqvist and assigned to Svenska Aktiebolaget Gasaccumulator, Lidingo, Sweden.

UNIVERSAL AND SLIP-JOINT ACTION for fluid-carrying lines subjected to pressure is covered in patent 2,511,495, assigned to Lockheed Aircraft Corp. by Andre Crot. A major disadvantage of conventional joints of this type—high friction between parts caused by unbalanced fluid pressure—is eliminated by balancing pressures to permit substantially unrestrained relative movement of the parts. A ball member held in a spherical seat carries a tubular member or sleeve with a closed end, O-rings providing sliding seals between the ball and its seat and between the ball and the tube. Holes in the side of the tube communicate with openings in the ball to permit fluid flow through

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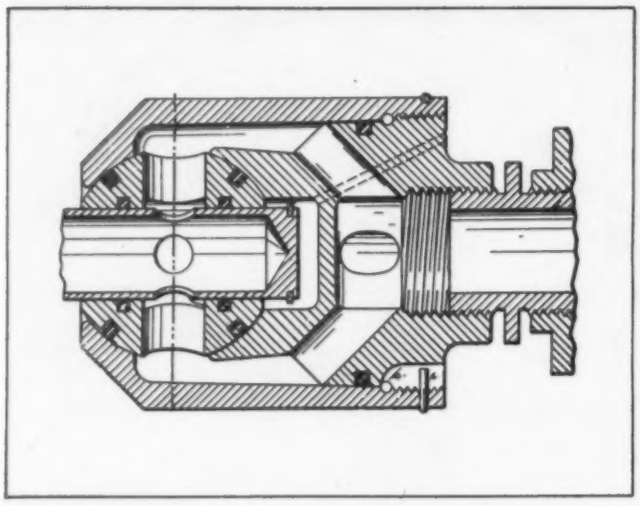
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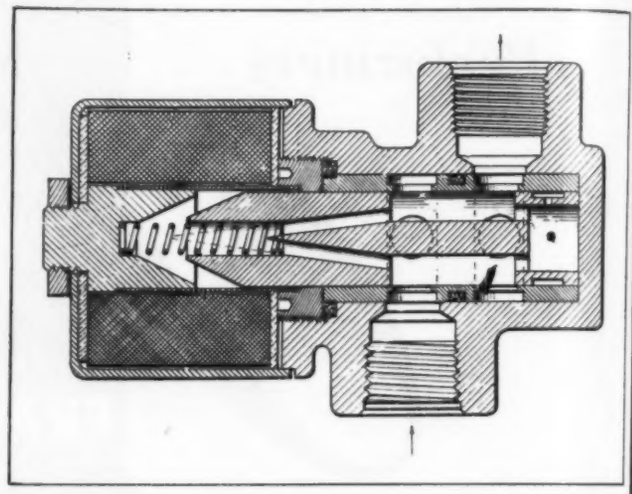
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the coupling. A chamber, vented to atmosphere, surrounds the closed end of the tube so that fluid pressure on the inside of the closed end of the tube balances the pressure acting on the opposing area of the line or fitting with which the tube is connected. The tube member is, therefore, hydraulically balanced and can slide freely within the ball, which is also free to move relative to its seat. This joint is particularly suited for use where high pressures and vibration are to be encountered.

REDUCTION OF FLUID FLOW in a hydraulically operated device as it approaches its end position can be accomplished with the solenoid-operated valve covered in patent 2,543,455. The valve, patented by George A. Goepfrich and assigned to The Skinner Chuck Co., uses a sliding spring-loaded magnetic spindle valve or plunger with different sized ports and a solenoid to give two flow rates. Energizing the solenoid slides the spindle to restrict the oil passages in the spindle sleeve for slow operation. When used in aircraft landing gear systems, the valve reduces the retraction rate just prior to the seating position and prevents undesirable shock on the landing gear system.



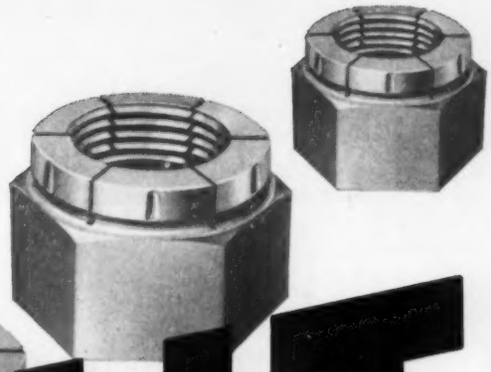


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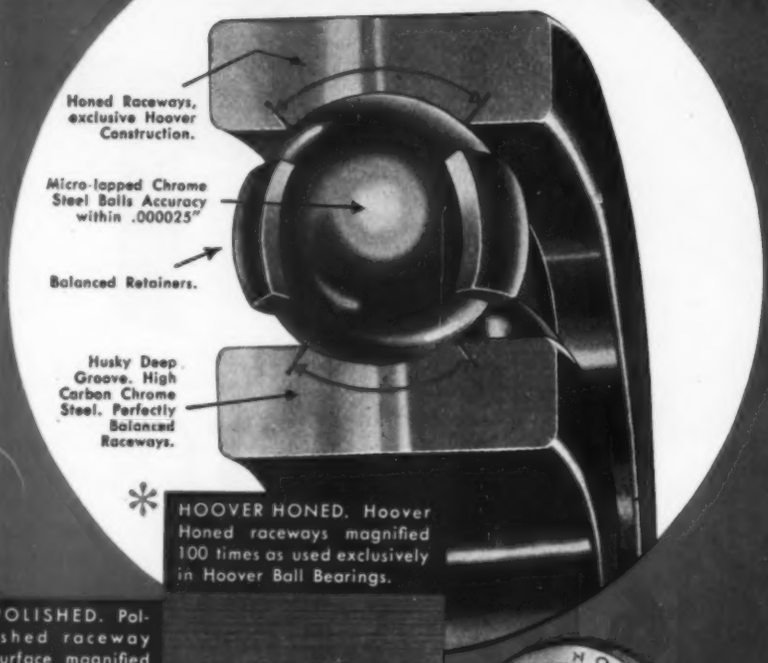
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Ann Arbor, Michigan

Design Abstracts

(*Continued from Page* 180)

stress for pinion and gear tooth respectively, psi

r, R = Operating pitch radius of pinion and gear respectively, inches

r_o, R_o = Outside radius of pinion and external gear respectively, inches

R_i = Inside radius of internal gear, inches

T_P = Pinion torque, pound-inches

Z = Length of line of action, inches

ρ_P, ρ_G = Radius of curvature at tip of pinion and gear tooth, inches

ϕ_n = Normal pressure angle, degrees

ϕ_t = Transverse pressure angle, degrees ($\tan \phi_t = \tan \phi_n \sec \psi$)

ψ = Helix angle, degrees

Calculation of the ***PVT*** factor for external gears involves the following formulas:

Radius of curvature in the transverse plane, at the tip of the pinion tooth,

$$\rho_P = \sqrt{r_o^2 - r^2 \cos^2 \phi_t}$$

and at the tip of the gear tooth,

$$\rho_G = \sqrt{R_o^2 - R^2 \cos^2 \phi_t}$$

Length of action,

$$Z = \rho_P + \rho_G - C \sin \phi_t$$

Maximum compressive stress, at the tip of the pinion tooth,

$$P_P = 2290 \sqrt{\frac{2\pi T_P C \sin \phi_n}{F Z N_P \rho_P (C \sin \phi_t - \rho_P)}}$$

and at the tip of the gear tooth,

$$P_G = 2290 \sqrt{\frac{2\pi T_P C \sin \phi_n}{F Z N_P \rho_G (C \sin \phi_t - \rho_G)}}$$

Scoring factor, at the tip of the pinion tooth,

$$(PVT)_P = \frac{\pi n_p}{360} \left(1 + \frac{N_P}{N_G}\right) (\rho_P - r \sin \phi_t)^2 P_t$$

and at the tip of the gear tooth,

$$(PVT)_G = \frac{\pi n_p}{360} \left(1 + \frac{N_P}{N_G}\right) (\rho_G - R \sin \phi_t)^2 P_t$$

The following formulas apply in the

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Height—20".
Diameter of base —18½".

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Seamless Drawn
Copper — 20 U.S. Ga.
Height—2½"
Width—6½"

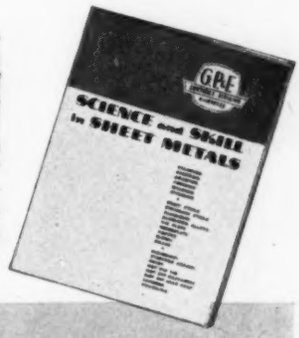
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ELECTRIC LIGHT HOOD



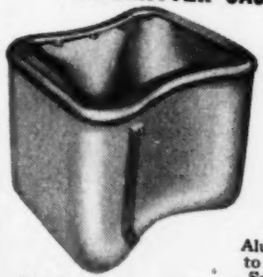
Seamless Drawn Steel —16 U.S. Ga.
Height—7½"
Diameter—6½"

MOTOR HOUSING



Seamless Drawn Steel—16 U.S. Ga.
Height—8¾"
Diameter—11"

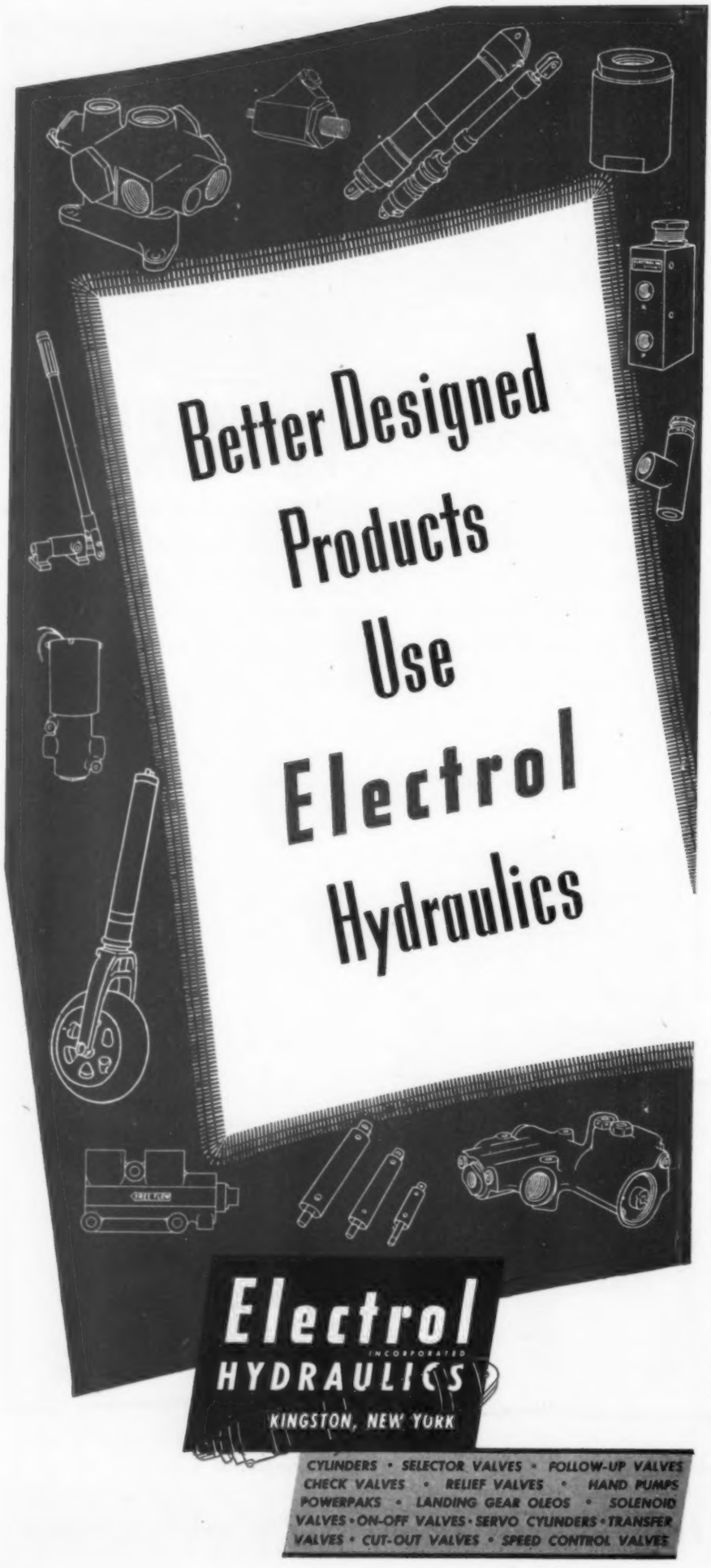
TRANSMITTER CASE



14 B & S Ga. Aluminum brazed to die cast ring—
Seamless Drawn
Length—10¼" Width—9½" Height—8¼"

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calculation of the *PVT* factor for internal gears:

Radius of curvature in the transverse plane, at the tip of the pinion tooth,

$$\rho_P' = \sqrt{r_o^2 - r^2 \cos^2 \phi_t}$$

and at the tip of the gear tooth,

$$\rho_G' = \sqrt{R_t^2 - R^2 \cos^2 \phi_t}$$

Length of action,

$$Z' = \rho_P' - \rho_G' + C \sin \phi_t$$

Maximum compressive stress, at the tip of the pinion tooth,

$$P_P' = 2290 \sqrt{\frac{2\pi T_P C \sin \phi_n}{F Z' N_P \rho_P' (\rho_P' + C \sin \phi_t)}}$$

and at the tip of the gear tooth,

$$P_G' = 2290 \sqrt{\frac{2\pi T_P C \sin \phi_n}{F Z' N_P \rho_G' (\rho_G' - C \sin \phi_t)}}$$

Scoring factor, at the tip of the pinion tooth,

$$(PVT)_{P'} = \frac{\pi n_p}{360} \left(1 - \frac{N_P}{N_G}\right) (\rho_P' - r \sin \phi_t)^2 P_P'$$

and at the tip of the gear tooth,

$$(PVT)_{G'} = \frac{\pi n_p}{360} \left(1 - \frac{N_P}{N_G}\right) (R \sin \phi_t - \rho_G')^2 P_G'$$

From a paper entitled "Shot Peening as a Factor in the Design of Gears," presented at the ASME Spring Meeting in Atlanta, April 2-5, 1951. Complete copies may be obtained from ASME, 29 W. 39th St., New York 18; $0.25 each to members, $0.50 to nonmembers.

Improved Machine Design

By H. G. Conway
British Messier Ltd.
Gloucester, England

IT CAN be said that machine design may be improved along three lines: those of function, cost, and appearance.

FUNCTION: Function relates to what the machine is and what it does, the performance that it gives, and its handling characteristics. From the point of view of selling the machine, it is its specification which is of prime importance. In comparing one machine with another, it is the specification which determines those factors which appeal most to the buyer and will influence his choice.

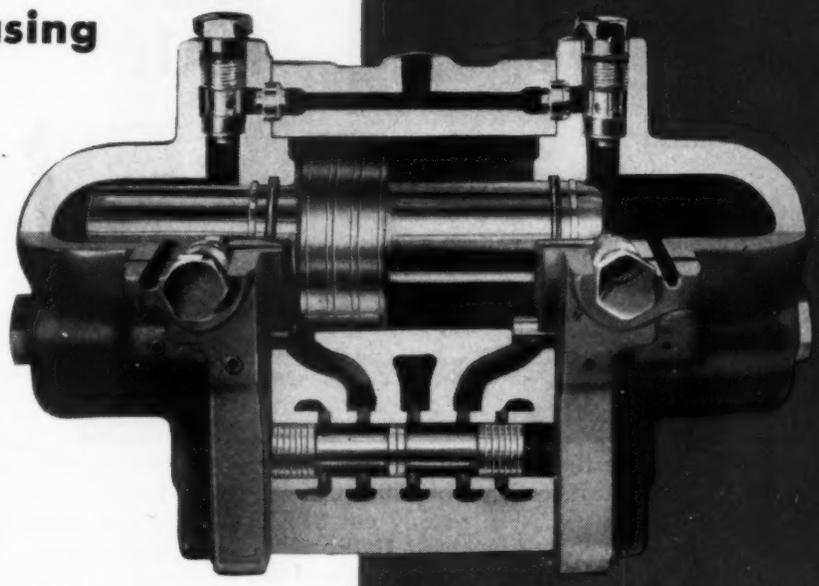
The second and, from some points

Multiply Pressure

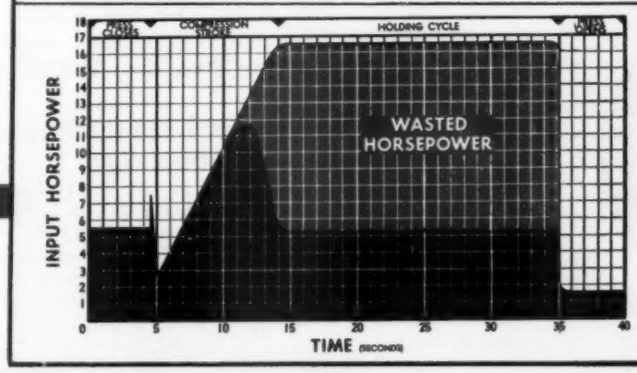
without increasing horsepower

On most presses and in many other applications, pressure requirements change during the operating cycle. The Racine "Variable Volume" low pressure pump with a Racine Pressure Booster can be used to develop and hold up to 5000 psi. The horsepower input does not exceed the power needed to operate the pump at its low pressure setting.

This means lower first cost, less horsepower consumption, reduced cylinder sizes — a more compact over-all design. Pressure and volume delivered can be controlled by one of the built-in governors that are standard for all RACINE pumps.



OPERATING ECONOMIES — *The colored area in the graph below shows the horsepower lost during one holding cycle of a simple press circuit using a constant volume pump. The black area shows the horsepower consumed when a Racine "Variable Volume" Pump and Pressure Booster is used to do the same work.*

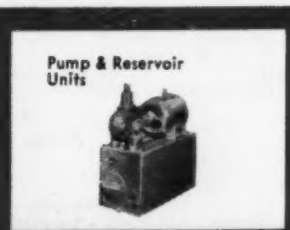


Write for new 3-color Catalog P-10-D covering RACINE'S complete line of "Variable Volume" Pumps, Valves and Pressure Boosters.

OTHER RACINE HYDRAULIC PRODUCTS







RACINE TOOL AND MACHINE COMPANY
1773 State Street, RACINE, WISCONSIN, U. S. A.



SPEED ALLOY
hot rolled ALLOY STEEL PLATE

This STEEL is a "STEAL"
when you consider the savings

IT sounds incredible that an alloy steel of Rockwell C 35 could be machined with a surface speed of 250 f.p.m. or more. Eagle Tool & Machine Co., Newark, N. J. readily cut SPEED ALLOY at that high rate of speed on their Cincinnati Hydrotel duplicating machine. Eagle feels that the easier machining qualities of this steel enable them to cut cavities for plastic molds at such low costs that results obtained are unequaled by other materials or methods.

On the cavity force, shown above, for molding a large home freezer breaker frame, SPEED ALLOY plates 5" x 32" x 62", were furnished heat treated to Rockwell C 35. Cavity was machined to 1" depth. Roughing cut was made with 5" milling cutter, cutting in full diameter to depth of ¼" with feed of 7" per minute; a maximum of 8¾" of steel removed per minute. By using pre-hardened steel there was no distortion due to subsequent heat treatment. Machined finish was like a mirror. Considering the initial low cost, machining costs and longer tool life, SPEED ALLOY is a "Steal"!



Speed Alloy Cams Carburized and Hardened With Practically No Distortion

This paper box machine cam is ⅞" thick, has track 1⅛" deep and 1¼" wide, leaving web only 3/16" thick. This is ample because of SPEED ALLOY'S high tensile strength and wear resistance. Despite thin web section cams were carburized and hardened with distortion held to .002" to .003". Made by S & K Tool & Die Company, Kalamazoo, Mich.

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W. J. HOLLIDAY & CO. (INC.)

SPEED STEEL PLATE DIV.
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Plants: Hammond and Indianapolis, Indiana

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of view, the more important direction in which machine function can be developed is by improvements to performance, reliability or life although these factors may sometimes in certain machines be considered as integral features of the specification. Each of these modifications is an attempt to give the customer a better machine. However, reliability and durability are factors which can rarely be proved by salesmen and, inevitably, experience is the only means of determining these aspects of performance. Markets are created by new features in the machine's specification but lost by failures of performance.

Study Performance Data

These two improvement factors of specification and performance usually originate, obviously enough, from sales or policy departments and often are more or less dictated to the designer. A very broad field, however, is before the engineer to make improvements based upon the practical performance of the machine in service and from data collected by laboratory research.

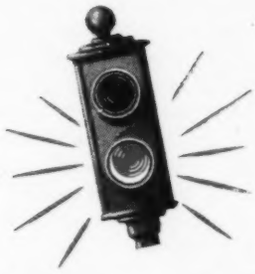
By far the most valuable source is field experience. Almost all organizations maintain service departments, field engineers of departments handling customers' complaints. These together provide a continual wealth of constructive criticism and information on performance which is usually substantiated by adequate statistics, particularly when the consumption of spare parts is analyzed and taken into account.

Analyze Criticisms from Field

Obviously defects in a machine are always reported in such a manner that they cannot be ignored. However, the more subtle defects are either inadequately reported or, as often, inadequately dealt with when reported. While it is true that no designer could possibly take action on all the defect reports that he received, it is equally true that many do not take sufficient trouble to analyze the reports and take appropriate action if action is possible. In this connection, a valuable addition to the staff of any chief engineer—if the service department is not responsible to him—is an investigation engineer or engineers capable of going out into the field and digging into performance defects themselves, specifically with a view to improving the product. A balance must be drawn between actual numbers of defects and the percentage of total production at fault, and the decision to in-

STOP AND GO

IS OUR BUSINESS

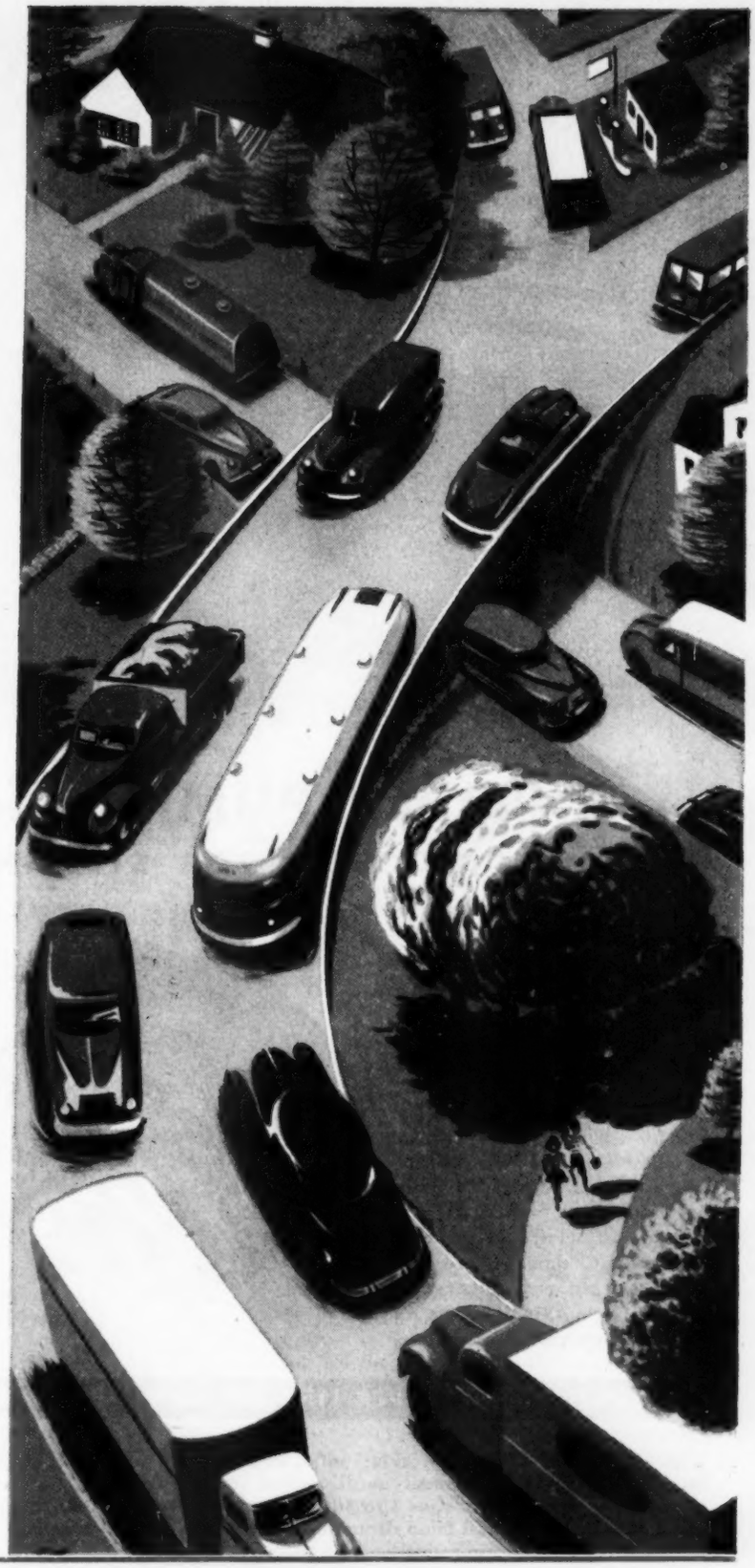


EVERYONE who drives . . . and that means everyone from the average motorist to drivers of the biggest buses and trailer trucks . . . wants safe, sure stops and quick, smooth starts. What they want takes the finest brake lining, brake blocks, clutch facings, and engineered automatic transmission parts.

That's why vehicle manufacturers, as well as makers of many other kinds of equipment, rely on Raybestos-Manhattan, the world's leading supplier of friction materials. They know from experience that R/M STOP AND GO products meet every requirement . . . can always be counted on for greater safety and longer, more economical wear.

R/M friction materials are serving today in applications that vary from heavy-duty trucks to tiny precision parts for adding machines. This diversity provides a breadth of experience that can be most helpful to you.

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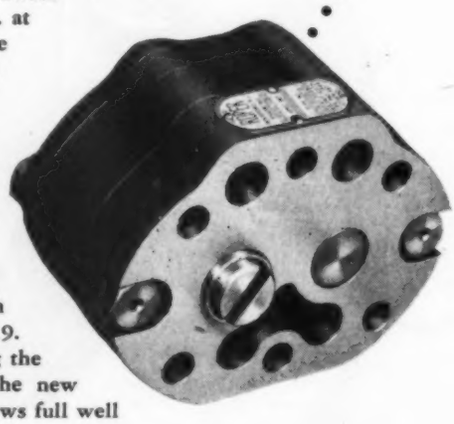
ALLIS-CHALMERS

HD-15 CRAWLER TRACTOR



SPECIAL ROPER PUMP POWERS HYDRAULIC BOOSTER FOR STEERING

This Allis-Chalmers HD-15 crawler tractor, which develops 102 h.p. at the drawbar, is one of four in the line that now sets a new standard in tractor classification. Among the components that keep this 27,500 pound bruiser going is a special Roper Pump — the power hydraulic booster control for steering. Engineered to withstand the most gruelling operating conditions, this pump has more than proved its worth in years of service in the HD-19. Now Allis-Chalmers is providing the same steering performance in the new HD-15. Yes, Allis-Chalmers knows full well Roper dependability.



INVESTIGATE THE ROPER LINE OF STANDARD PUMPS

Roper "Standard" Pumps — Series 3600, F, K, and H — also figure prominently as original equipment in diversified installations. These Ropers provide a wide selection: sizes 1 to 300 g.p.m.; pressures to 1000 p.s.i., and come standard or special fitted depending on the liquid to be pumped. *Send for the Roper catalog and get complete details.*

ROPER Rotary Pumps

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troduce an improvement is not one which can be lightly made, particularly when interchangeability is affected.

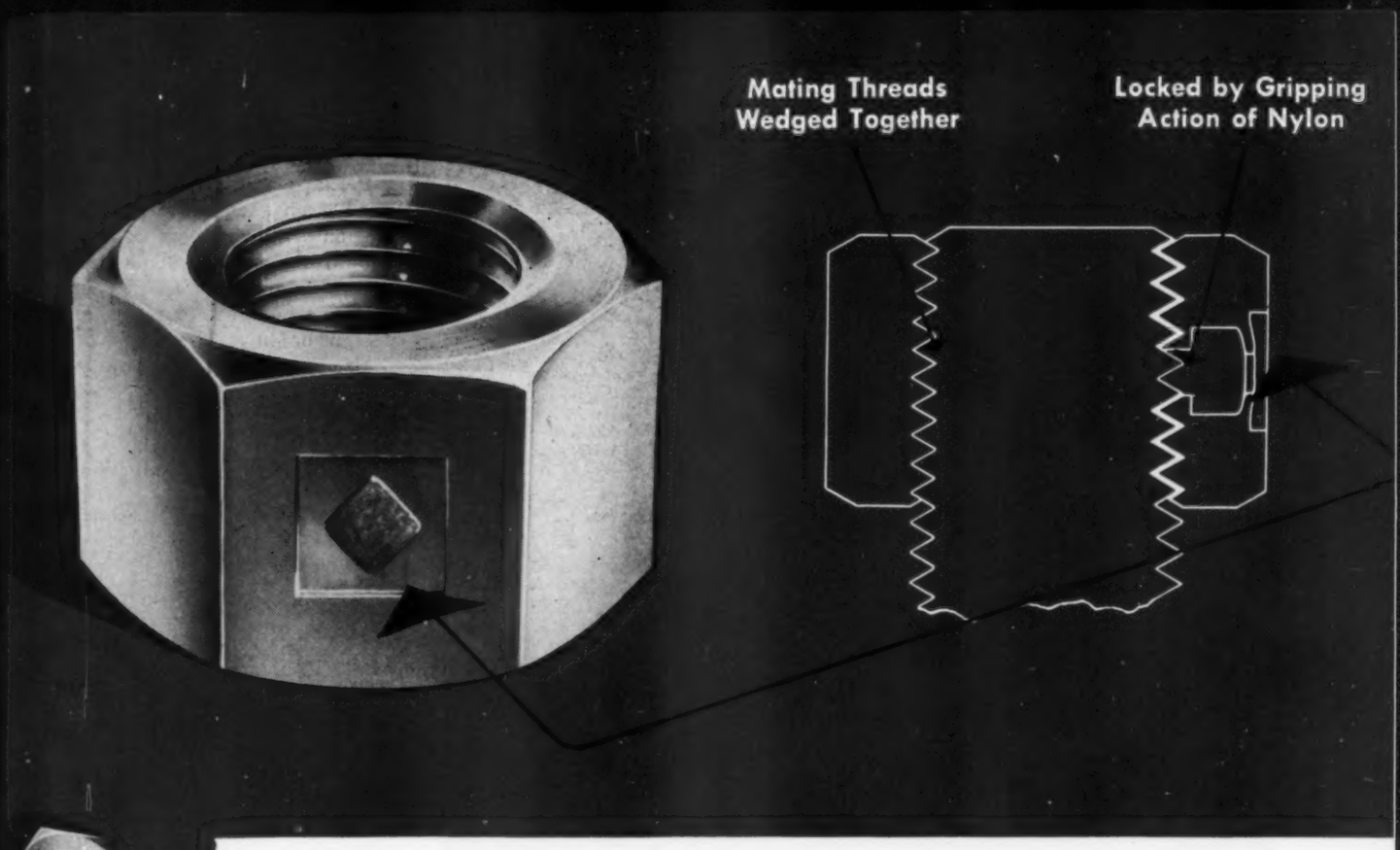
There is another broad field of work, classifiable under the heading "product research," in endurance or bench testing, laboratory investigation and particularly the make-and-break technique. The general philosophy of this work is deliberately to run the machine to destruction, repair the failure by a suitable redesign and continue the process until further failure occurs. It is generally found that, if this process is carried out for many hours, thousands of cycles, etc., the final result is a product which is rarely more expensive, heavier, or worse looking and has a life of several times the original component. Experience indicates that the final product is, in fact, often appreciably simpler and cheaper. The durability of almost all comparatively complicated mechanisms can be improved in this way. This technique applied to static structures in the aircraft industry has enabled airframe elements to have their effective strength increased, often by as much as 100 per cent, by repeated static testing until failure occurs, with successive redesign of local areas of failure. The net result is a structure which makes full use of local strength form factors and which has the optimum strength-weight ratio.

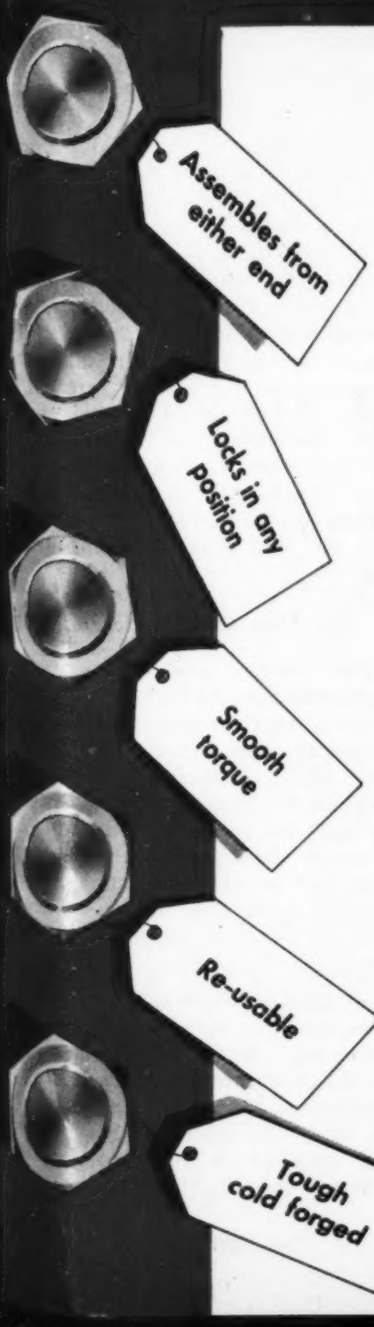
Learn by Overload Testing

While this make-and-break technique is to some extent what is almost always carried out during the development of the prototype or experimental component in every firm, it is the deliberate overloading technique which is less usual and can be so valuable in the subsequent improvement of the machine. If sand causes wear, running with excessive sand is the quickest way to find out how to improve sand resistance. If high speed causes bearing failures, running at high speed will be the quickest way to develop improved bearings.

MANUFACTURING COST: Manufacturing cost is usually studied in relation to the production process and the design, apart that is, from reductions in cost by overhead economies or by improved business efficiency. The latter are, in themselves, able to effect appreciable savings but they are not, at least directly, the province of the mechanical engineer.

The production engineer's job is to reduce cost by reprocessing, by installing new plant and equipment to enable economies to be made, and by introducing quantity production tech-





Easy Does It With
Townsend Nylok Locknuts

It's *easy* to install the new Townsend Nylok Self-Locking Nut* as it has no top or bottom—it assembles readily even in blind applications. In addition, you get positive locking action with low installation torque. This saves time and reduces scrap losses due to seizing and galling by as much as 80% over other types of locknuts. Lock washers and jam nuts are eliminated.

The Townsend Nylok Type "E" Nut is cold forged to provide added strength in the body and threads and to save critical material compared to nuts machined from bar stock.

The small nylon plug insert located in the center of one of the hex faces provides the locking action. This plug extends beyond the crest of the threads in the nut and when the nut and bolt are assembled the bolt compresses but does not cut this nylon plug. The nylon plug then reacts as a wedge creating strong metal to metal action between the male and female threads.

*Licensed under The Nylok Corporation patents.

Nylok nuts lock in any position. Seating is unnecessary. Due to nylon's ability to retain its original shape, these nuts can be used again and again. This feature makes it especially desirable in setting adjustment screws. Nylok nuts have high tensile strength, excellent heat resistance and are unaffected by most chemicals.

The Townsend Nylok Locknut is available in American Standard Light (E-6) and Light-Thick (E-7) series—in sizes ¼" through ⅜". It is a suitable companion to Townsend's Tufflok Nut which is a one-piece cold forged nut, with a hexagonal fibre washer as the locking medium. Both locknuts have been highly successful in offsetting vibration and shock. They have back of them Townsend's 135 years of experience in wire drawing and cold heading.

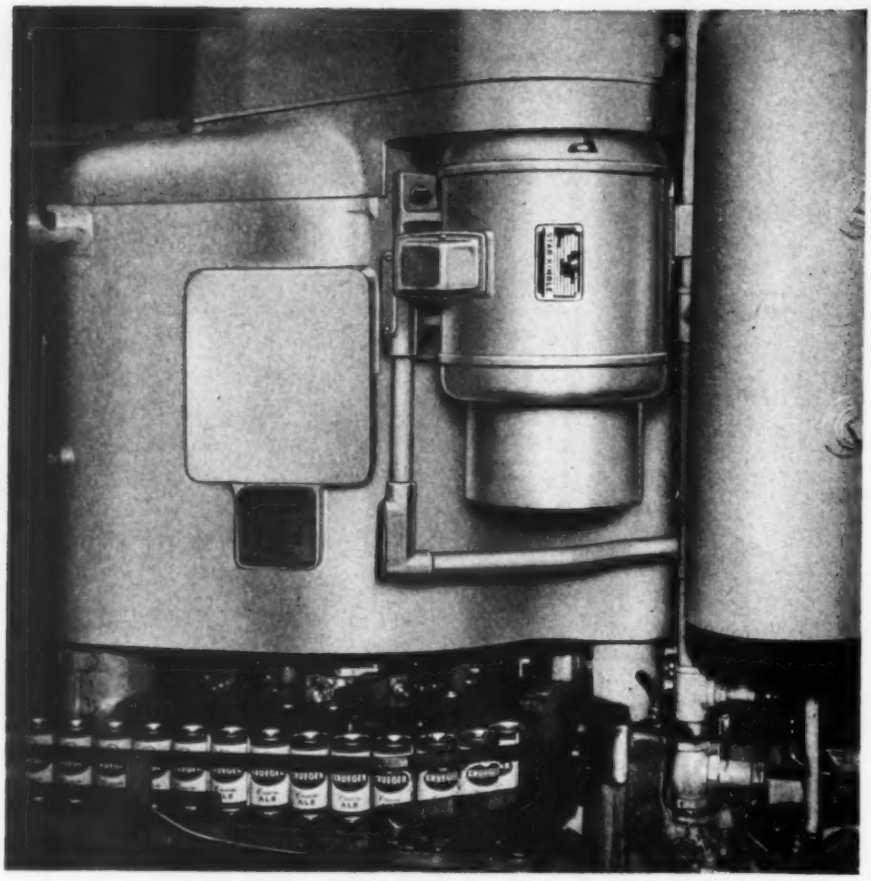
For information on how to save time, eliminate waste and produce better equipment with Townsend Locknuts, write for our locknut bulletin.

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...with Star-Kimble Brakemotors on American Can Closers

THERE'S scarcely a chance that a can will jam on a closing machine built by American Can Company—but American *takes every precaution to avoid jamming damage.*

In the machine shown, which seals 300 cans a minute at the Newark plant of the G. Krueger Brewing Company, power is automatically cut off if jamming occurs. Then a Star-Kimble Brakemotor brings the machine to a stop within a single can cycle—that means *within one-fifth of a second!*

Whether split-second stops like this are needed only in an occasional emergency . . . or whether the service calls for *repeated* start-stop cycles at short intervals . . . you can count on the *extra-large* disc area of a Star-Kimble Brakemotor to provide *extra-fast* braking and positive holding. *Starts* are fast and smooth, too—free from friction drag. Small magnetic air gap assures speedy brake release.

In thousands of applications, under the toughest conditions, Star-Kimble Brakemotors have proved their ability to run for years with little or no attention. *Remember* . . . with its motor and brake *built* together to *work* together, each Brakemotor is an integral, space-saving unit *designed* for its specific job by the pioneer makers of disc brakemotors, and *backed* by more than 25 years of application experience.

For full information on construction and ratings, write for free Bulletin B-501-A.

STAR-KIMBLE

MOTOR DIVISION OF
MIEHLE PRINTING PRESS AND MFG. CO.

201 Bloomfield Avenue Bloomfield, New Jersey

niques. All these are well known and continually practiced.

Perhaps not quite so widely practiced is an adequate degree of co-operation with suppliers of material or bought-out parts. Some firms have purchase departments who are either able to contribute to the technique of design or have arranged an appropriate degree of collaboration with the design department to achieve this object.

Design for Production

The possibility of reduction in cost by redesign is a most fascinating aspect of modern engineering and cannot possibly be treated adequately in a few words. The most obvious method is in "designing for production," this implying the detail study of each component so that unnecessary operations are eliminated and the remaining operations can be carried out in the simplest and most expeditious fashion. An important part of this particular job is the scientific application of tolerances — about which many oft repeated but usually justified platitudes have been expressed.

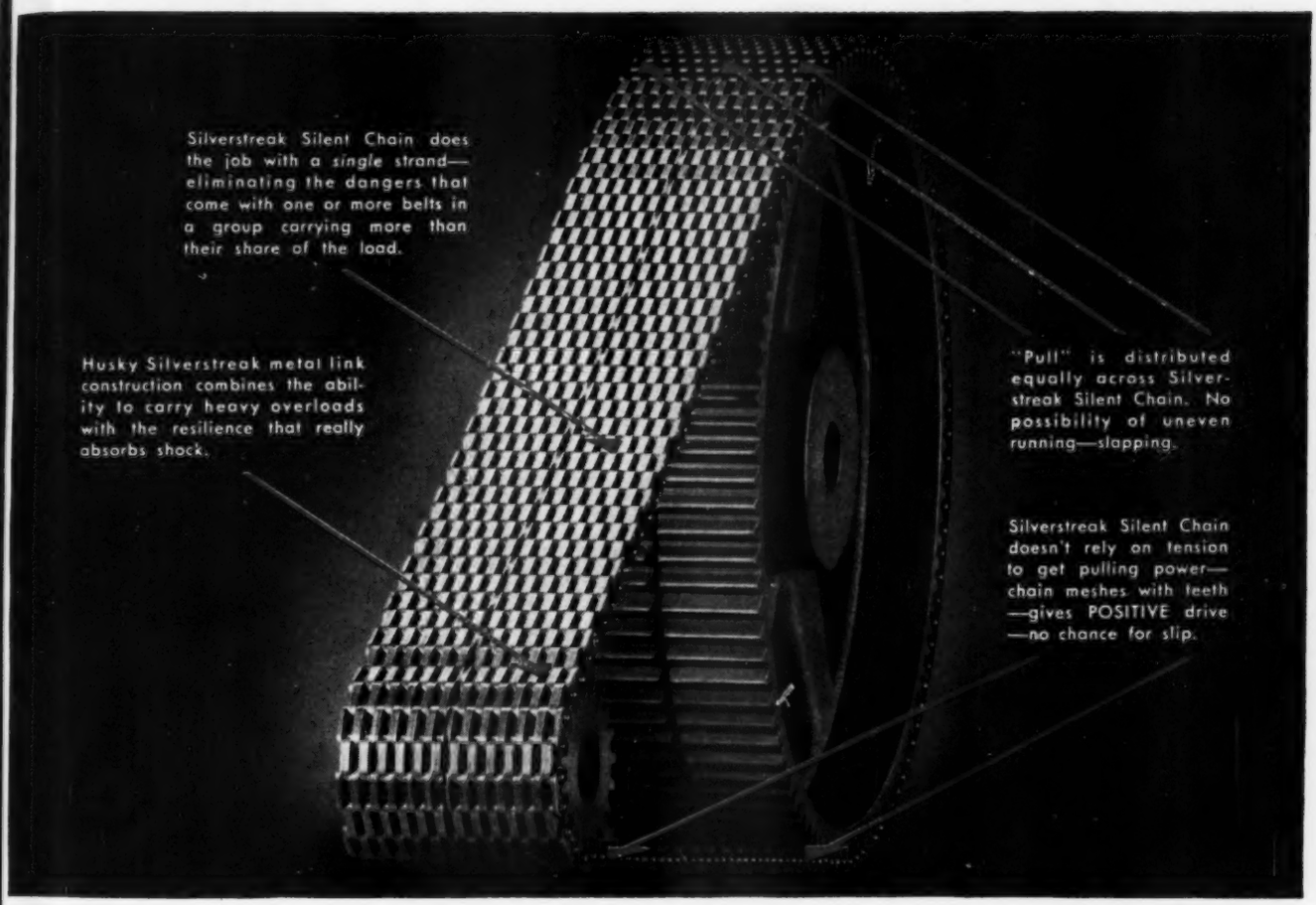
However, possibilities not generally appreciated exist in the concentrated application of ingenuity and inventive steps by special design effort, possibly by specially trained teams. In the author's experience of the design of new components, discussion and argument among the senior engineers usually result in the invention proper in the form of a sketch of the idea to solve the problem. An average of four redesigns are necessary (at any rate on the type of precision mechanical device within the author's experience) before the design is ready for detailing.

Be Alert to New Materials

The development of new materials, particularly synthetic substitutes with attractive properties, enables continual improvements in design to take place. This is usually outside the sphere of the mechanical designer but it is for him to find means of exploiting them. Similarly, the exploitation of new fabrication and assembly techniques is an essential part of reduction in cost by redesign.

STYLING OR INDUSTRIAL DESIGN: The final direction in which machine design may be improved is in its "styling" or specialized design for appearance. The artist has a job to do after the mechanic has finished, but inevitably in co-operation, whether the artist and mechanic are

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the same man or whether the artist is an industrial designer. Artistic design in itself is necessary to stimulate sales and, at least from many people's point of view, for basic esthetic reasons. Whether the engineer agrees that he has this esthetic responsibility may be a matter of opinion, but few will disagree that the general appearance and "tidiness" of a machine are important factors, particularly where they are manually operated and where the psychological appeal of the machine is important. The color and finish of the machine are matters of consequence; the decorative relief, however, is a matter which often occupies the attention of the industrial designer but which the mechanical engineer is likely to regard with suspicion.

Engineering designers are only human and subject to the same likelihood of making mistakes as anyone else. It does seem strange, however, that large organizations with first-class staff and facilities should make such obvious mistakes as they sometimes do. Fine appearance involves two important factors: the training of designers (or engineers) to achieve an adequate level of esthetic ability; and the taste or critical ability of the purchaser or user of the machine.

The Esthetic Problem

The problem of teaching an engineer to produce designs of fine appearance is as complicated as teaching art students how to paint fine pictures. From a batch of one hundred art students, work of a high artistic standard may be expected from, say, fifteen, but a minor masterpiece in oils from not more than one. On the other hand, after a few years of training at least fifty to sixty of the pupils could be expected to produce a reasonably pleasing poster or advertising layout.

To expect the engineer to do any better in his own field is unreasonable; but he can be expected, after suitable training, to produce "reasonably pleasing" machine designs or at least to avoid particular ugliness.

Just as the musician will distinguish between tempo and rhythm, so the artist can distinguish between composition and design. The following quotation, although not referring specifically to design in the sense that the industrial designer uses it, is very appropriate when read as if it did so refer:

"Composition is a term which . . . denotes something to be distinguished from the quality of design. (We) see it as a negative virtue, a code of good manners which can be

PRECISION COMES IN ANY SIZE FARREL® GEAR



from 1/4 inch to 20 feet in diameter

Farrel herringbone gears are made in a complete range of sizes from 1/4 inch to 20 feet diameter, 1/4 to 60 inch face, 24 DP to 0.75 DP, for any power capacity and any application. The quiet, vibration-free performance and long life you can expect from these gears result from extreme accuracy of tooth spacing, contour and helix angle . . . qualities inherent in the Farrel-Sykes method of gear generation.

Straight tooth (spur) gears and single helical gears are supplied in any size from 1/4 inch to 20 feet diameter, 1/4 to 30 inch face, 24 DP to 0.5 DP. Also available are large internal gears, with either spur or helical teeth, in sizes up to 16 feet diameter, 12 inch face, 1 1/4 DP.

Farrel engineers will be glad to assist you in working out unusual gear problems. Information about Farrel precision herringbone gears, or any of the other types mentioned on this page, will be sent on request.

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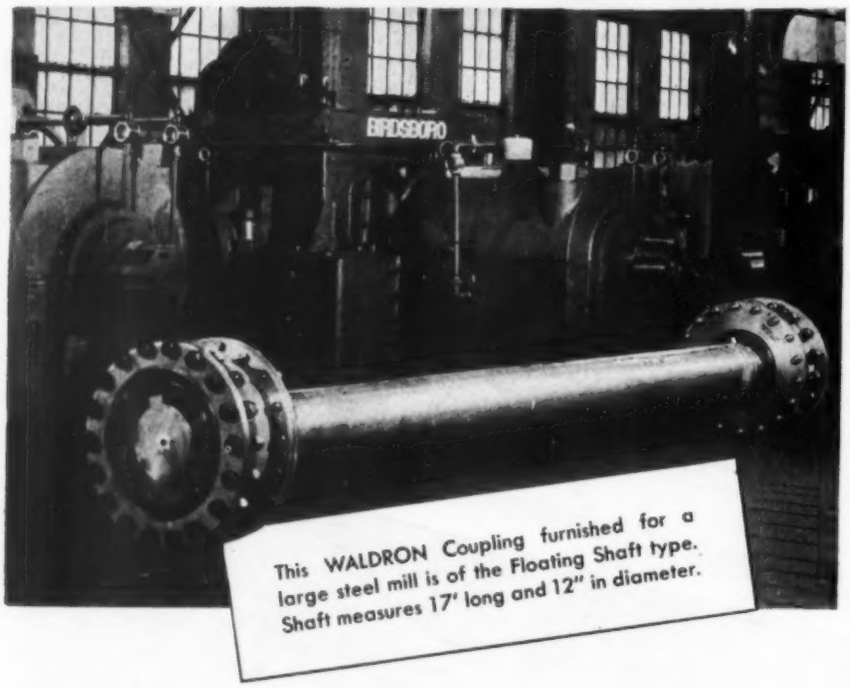


FB-673

For The RUGGED Jobs...

WALDRON Improved Gear Type COUPLINGS

get the nod!



This WALDRON Coupling furnished for a large steel mill is of the Floating Shaft type. Shaft measures 17' long and 12" in diameter.

they are built for dependable service

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Large or small—every WALDRON Coupling is designed and built with typical operating troubles in mind. Forty years of experience has taught WALDRON engineers the pitfalls to be avoided in producing a dependable coupling. The WALDRON design eliminates the usual sources of trouble; the WALDRON construction is simple and strong—forged steel parts, no welded sections, better lubrication.

The steadily growing preference for these sturdy WALDRON couplings in all major industries is a tribute to the quality and workmanship that goes into them.



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explaining coupling features which give added insurance against coupling failure. No obligation.

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CORPORATION
New Brunswick, New Jersey

Authorized Sales Representatives in Principal Cities

learned and which will prevent the worst mistakes, but which, in itself, is not anything creative. Satisfactory composition—that is, the general rough-and-ready framework of placing—can be achieved very often by, say, altering . . . (proportions, radii, countersinking screws, etc.); but this is only the first stage, the (machine) must then be compacted with meaningful relationships by those all-over reciprocal adjustments of interval between form and form . . . which constitute Design. The intuitive apprehension involved in this process is something that cannot be taught; it can only grow out of the sensibility of the individual" (Hardy 1950).

Or again,

"The function of ornament of the static type is that of punctuation and emphasis: the eye must be arrested here, continued there, to complete the composition. This same function is performed in a subtler and less ostentatious way, but no less an essential one, by groups of moldings whose interplay of widths and depths modifies the harshness of sudden openings and endings and prevents bald right angles from interrupting the organic unity of the (machine). In many cases so strong is the need for this kind of modification, if the harmony of the whole is to be maintained, that a system of cursive ornament has to be introduced" (Byron, 1932).

Learn What Not to Do

The problem can thus no doubt be simplified into this: Composition in the sense of what not to do, what mistakes not to make, can and should be taught to engineering designers; good industrial design, however, is an intuitive quality possessed by but few engineers.

The engineer will ask what the rules of composition are, particularly of architectural design, which seems most appropriate to the three-dimensional machine. Usually an initial division is made between static composition, involving a center of focal point to which the pattern, line, and shape of the design should lead, and dynamic or mobile composition where pattern, line, and shape repeat and lead the eye along or about the composition. There are a few rules which can be found in textbooks, mainly relating to certain proportions for solid bodies, but on the whole it is easier to say what not to do; if all the rules were to be found in a textbook, art would have given way to science.

But the engineer will understand that, even if he knew all the rules of

composition and design, he could not apply them to machine design without seriously interfering with functional and operational requirements. Only in the case of machines which are deliberately covered in with housings or casings could even an elementary attempt at esthetic design be made.

Critical Power Not Inherent

The critical appreciation of beauty is not innate in the ordinary man, or at least it requires considerable molding and experience.

Color involves questions of taste and surroundings. Uncultivated taste generally prefers bright colors, as on machines exported to undeveloped countries or on agricultural equipment. Dark colors offset by polished metal or matte chromium finishes are suitable for precision equipment. Pale colors, including white, are suitable for equipment used in clean surroundings and where the machine itself can be kept clean—for example, dental or X-ray equipment.

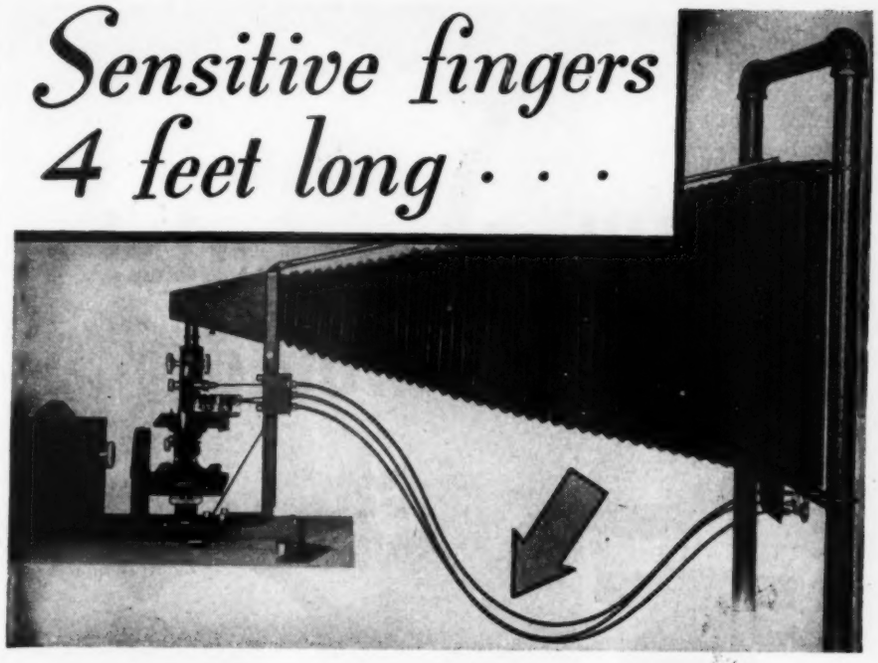
From a paper entitled "Industrial Design and its Relation to Machine Design," presented at a General Meeting of The Institution of Mechanical Engineers in London, England, February 2, 1951.

Stresses in Automotive Parts

By Robert Schilling
General Motors Corp.
Detroit, Mich.

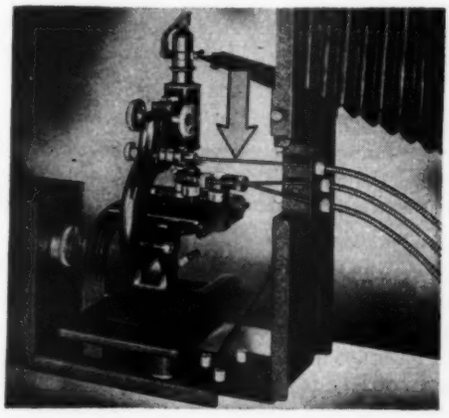
AUTOMOTIVE engineers hardly ever know the true stress which exists in their products in service, but they do know that these products will stand up in reasonable usage for the life of the car, and will fail early under extreme abuse. They come by this knowledge sometimes through road testing alone, but in many cases they can predict the performance by combining service observation, strain measurements, and simple analysis. Automotive engineers are often accused of paying little attention to stress analysis in designing parts and components, and of proceeding too much by rules of thumb and by cut-and-try methods in developing the strength and durability of their products. It is quite true that the method of finding proper shapes and dimensions for highly stressed parts in automotive engineering makes more use of empirical informa-

Sensitive fingers 4 feet long . . .



FOCUS A MICROSCOPE

They're S.S.WHITE remote control type flexible shafts. As the illustrations show, they connect the microscope's three focusing knobs to control knobs 4 feet away. And they fully satisfy the application's need for close, sensitive manipulation. They would do this whether the distance was 4 feet or 40—because S.S.WHITE remote control flexible shafts are engineered and built expressly to provide smooth, sensitive remote control. They have the necessary characteristics for the job.



Close-up shows how flexible shafts are connected to microscope of the Microprojector shown above. The enlarged image of the microscope's field is thrown on a translucent screen on the right end. From a position in front of this screen the operator focuses and centers the image.

Photos courtesy Mine Safety Appliances Co., Pittsburgh, Pa.

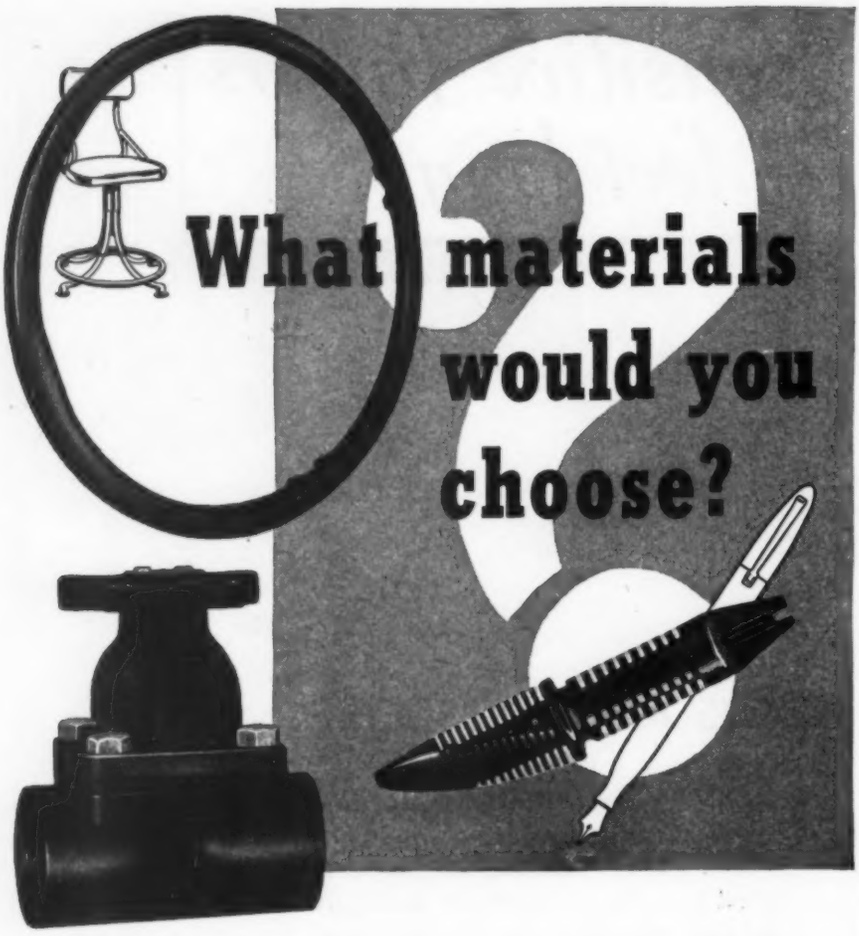
WRITE FOR BULLETIN 5008



It gives engineering data about S.S.White flexible shafts and tells how to select and apply them. Write for a copy today.

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NEW YORK 16, N. Y.



1. FOOT RING FOR STOOL: Designers sought strong, abrasion resistant, smooth material that would never snag telephone operator's nylons, while resting her feet up off cold floor. What material would *you* use?

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Yes, sometimes it's hard rubber, and sometimes it's one of the other plastics that's best. Ace, with many hard rubber and plastics compounds to choose from, is fully equipped to supply whatever you need.



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tion and less of analysis than that used in many branches of mechanical engineering. However, when we follow the steps by which we arrive at the proper design and size of our machine parts, we find that they form a sound line of reasoning.

Service Stresses Uncontrolled

In most branches of engineering design, stresses are so chosen that no failures shall occur in service. In automotive engineering, the magnitude of service loads is not definitely limited; abusive driving or bad roads may produce extreme loads which occur possibly once in the life of a few cars, so that it would be uneconomical to provide sufficient strength for these rare conditions in all cars built. A standard for design stresses, hence, can apply only to certain road conditions and driving practices, and will aim at freedom from failure below a limited load and for a finite life. But this means that failures under extreme overload are expected and the designer must therefore consider their nature and prevent unsafe failure as far as possible.

The design practice begins with the observation of failures either in service or in laboratory test of complete machine parts. It leads to an empirical expression relating nominal stresses, calculated in a specific way, to the characteristics of the material. The stresses calculated by these equations are not intended to represent true stresses, but are simply a measure of the severity of service loading and durability. Such a relation is only applicable to one type of element manufactured in a certain manner and used in a specific type of service. In spite of these restrictions, this information permits extrapolation to applications which at first sight seem totally different. Many developments in railroad and marine transportation and designs of ordnance vehicles have been based on passenger car practice and proved to be highly satisfactory.

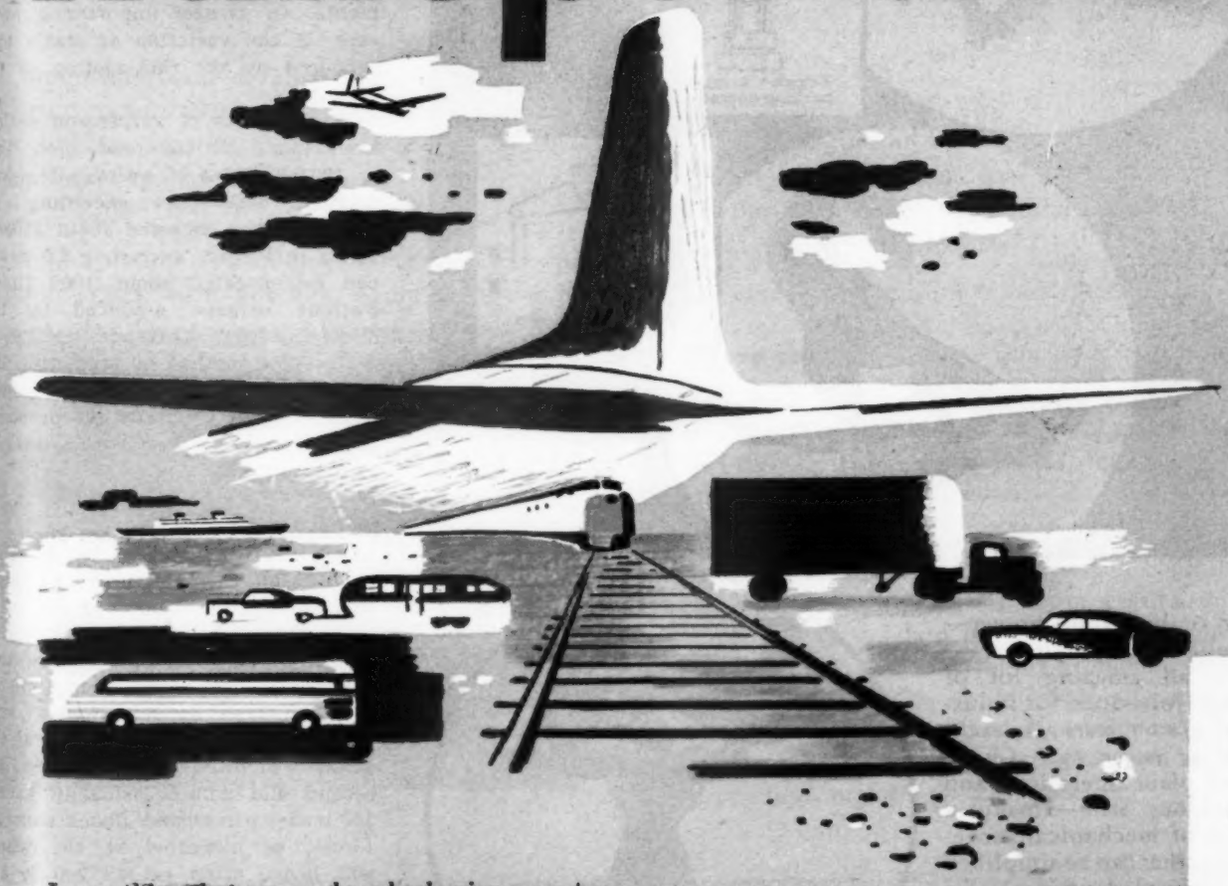
Stress Can Be Related to Material

The relation between nominal stress and physical properties of the material can give a reliable measure of the severity of loading, provided the stress equations are properly interpreted and their limitations are considered.

Disregarding failure due to extremely high or low temperature, chemical attack, fretting, and to wear, we shall discuss here only structural failure due to stress at moderate temperature. There are two distinctly different types: failure under a single

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transportation



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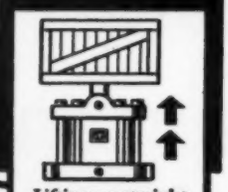


Toggle—a typical pushing operation.





Pulling—as shown in 1st class lever.



Lifting—a straight thrust movement.



Air or hydraulic power—applied by T-J Cylinders—gets an amazing lot of tough jobs done for industry . . . *faster, more efficiently,* and *at lower cost!* Check your plant operations and machines *now* — make a note of mechanical movements that can be simplified and speeded up with T-J Cylinders! Designed for a wide range of pushing, pulling, lifting, clamping or control jobs . . . 100 lb. or 50,000 lb. Many standard sizes and styles . . . both cushioned and non-cushioned types . . . precision-built, dependable. Write for additional information. The Tomkins-Johnson Co., Jackson, Mich.

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load cycle, usually called static failure; and failure under repeated load cycles, called fatigue failure.

There is no complete information on all loads which automotive parts must withstand. Some are known from strain measurement carried out on the road, others from deflection counts, and many can be inferred from the laboratory test durability which is required for failure-free service. In general, the last is the most reliable way of expressing the requirements.

Static Load Variation Important

Static load appears as cyclic load on rotating parts such as tires, wheels, bearings, and axle shafts, and hence determines a part of their requirements. Of greater importance, however, is the variation of static load produced by the ride motion of the car.

Some counts of suspension deflections made on the road show that in 100,000 miles of average highway driving, deflections exceeding 1.6 inches can be expected about 250,000 times, deflections exceeding 3.0 inches can be expected about 4000 times. Fatigue damage produced by the small and large strokes is cumulative. No reliable method of predicting life under such mixed cycling schedules is known, but generally the predominant damage is done by the largest stress cycles.

Shock Absorber Forces High

Shock absorber forces caused by deflections of the suspension are often larger than the variation of spring forces. Road tests have shown that at the hop frequency of the wheels, (10 to 12 cycles per second), the vertical velocity, as measured at the wheel, will often reach 50 inches per second and will occasionally exceed 100 inches per second. Shock absorber forces, as measured at the wheel, will hence often exceed 200 lb and sometimes 300 lb, depending upon the valving used.

Beyond 3-inches compression, measurements of deflection do not permit a good estimate of forces, since rubber bumpers increase the wheel forces rapidly. However, such large deflections are rare and static failure becomes most important. Parts subjected to these forces show static load capacities of approximately four times static load, (5-passenger load), on passenger cars. On cross-country vehicles, the required capacity may be between eight and ten times static load.

Lateral forces between tire and

The problem was...

How to get extra copies of blueprints—

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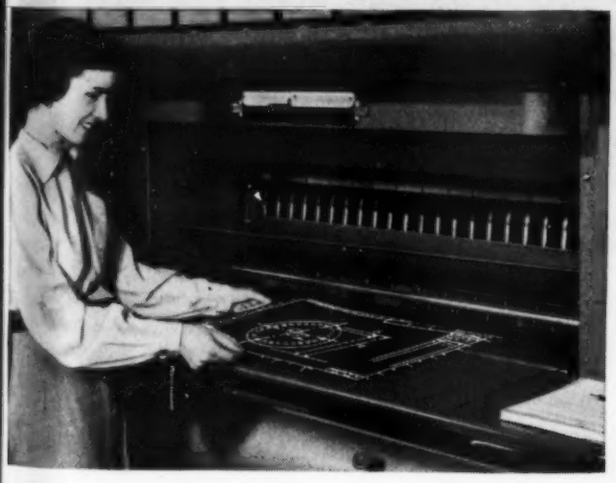


A case history based on the experience of the American Brake Shoe Company, Kellogg Division, Rochester, N. Y.

The blueprints (and direct-process prints) submitted by customers placing machining orders used to be a problem for the Kellogg Division, American Brake Shoe Company.

Invariably, prompt delivery was requested. But... before production could begin, extra copies of each customer-print were needed. Being semi-opaque, these prints could not be used as print-making masters in Kellogg's direct-process machine. How, then, could the extra copies be obtained in the shortest time... and at the lowest cost?

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Now... extra copies are made quickly... economically

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The operation is simple... is performed under ordinary room light. Autopositive Paper is exposed in contact with the customer's print in Kellogg's direct-process machine. It is then processed in standard photographic solutions. The result is a sparkling, long-lasting, highly legible photographic reproduction—dense blacks, clean whites—on a durable, evenly translucent paper base. From this Autopositive intermediate, the required number of extra copies can be turned out... at practical, uniform machine speeds.

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Gentlemen: Please send me a copy of your illustrated booklet giving all the facts on Kodagraph Autopositive Paper. 19

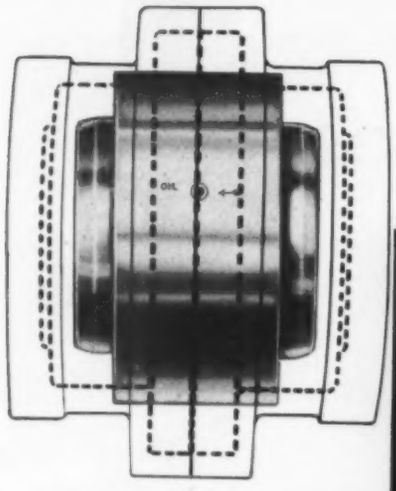
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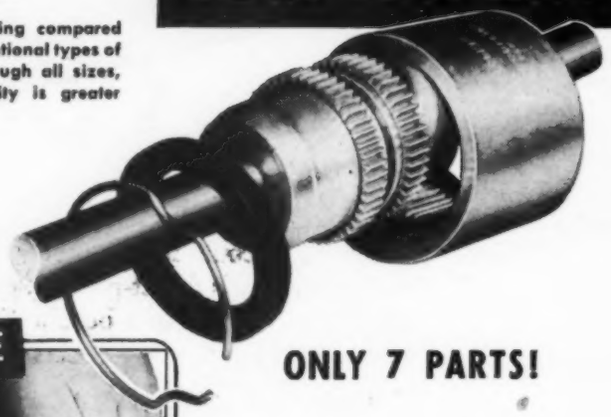


Sier-Bath Gear Coupling compared with two major conventional types of same shaft size. Through all sizes, Sier-Bath's HP capacity is greater than either.

- 3/5 Usual Size
- 1/2 Usual Weight
- Assembled in Seconds

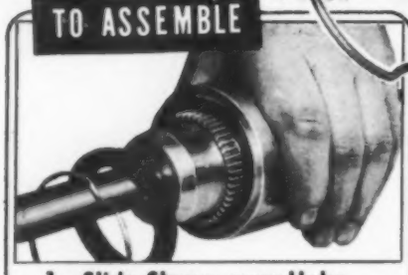
NEW Sier-Bath Flexible GEAR COUPLING

Ready for Assembly

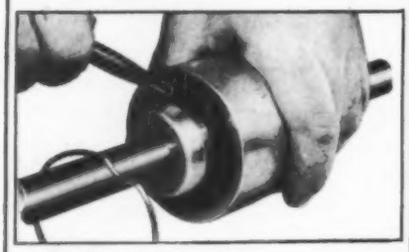


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1—Slide Sleeve over Hubs . . .



2—Press in Seal . . .



3—Snap in Snap Ring!

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This simplification does not alter the basic flexibility of the gear type. The Sier-Bath Coupling handles the usual amount of angular and offset misalignment, and end float. And, being smaller and lighter, it puts less strain on shafts and bearings.

With no bolts to shear, seize, strip or corrode, the new coupling is more dependable and durable. Though the snap rings are installed by hand and removed with a small screw driver, they will withstand 50,000 lbs. of end thrust. The neoprene seals are *guaranteed* leak-proof—the hubs and sleeve are made from steel forgings with 90,000 lbs. tensile strength. Silent operation and long life are insured by precision cut internal teeth, and the design provision that *all* the load is carried on *all* the teeth *all* the time.

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road during cornering rarely exceed 40 per cent of static load on the outer wheel, and the highest that an abusive driver may impose is probably not above 60 per cent. On rough or rutted roads, forces of this order may appear in straight-away driving, and even larger loads may be imposed occasionally during curb jumping or overturning.

Traction Limits Some Forces

Forces due to traction and braking are limited by the traction coefficient between tire and road. A value of unity for this coefficient seems to be the maximum, and designs based on this figure have been satisfactory if the weight transfer between front and rear during acceleration or deceleration has been considered. Driving torque is also limited by available engine torque.

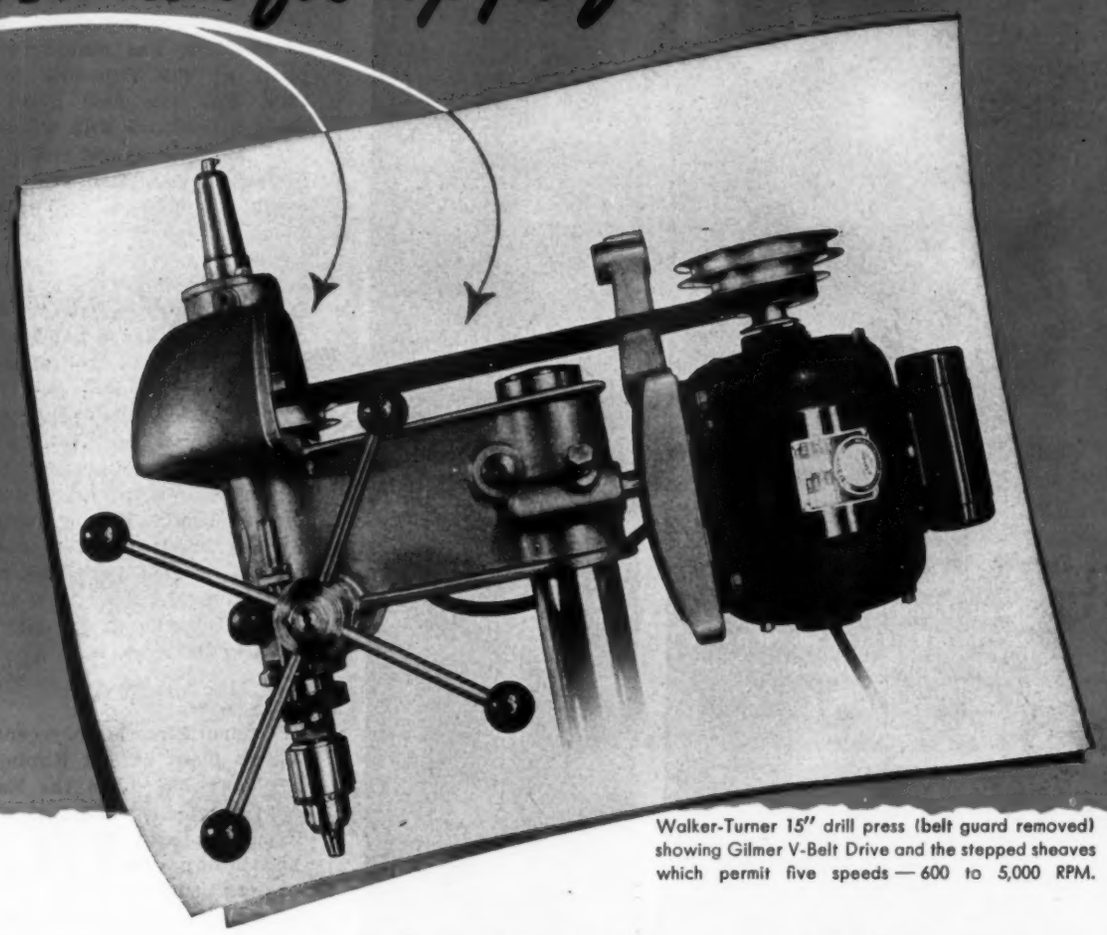
Vibrations can appear in many forms, such as torsional and bending vibrations of the crankshaft, propeller shaft whip, shakes induced by the suspension, and others. They can produce many cycles of large stress amplitude and will therefore require high fatigue durability in the affected parts. However, such vibrations must be suppressed for reasons of passenger comfort alone, and therefore they will only rarely determine the standard of durability.

Collision Resistance

Resistance to collision damage is not usually a design requirement, and it varies greatly between such parts as bumpers, fenders, body panels, and chassis members. But during experience with past cars, owners and service men have come to expect a certain performance, and if a new design is more vulnerable, there will be many complaints. Few numerical data are available and the tolerances are wide, especially where considerations of styling predominate, but one example may be of interest to chassis designers. When wishbone type front suspensions were first introduced, the shock absorber and its arm formed the upper wishbone. Although this construction, as designed, was satisfactory in normal service, complaints of frequent collision damage forced its redesign so that the assembly would withstand a longitudinal horizontal force of approximately 3000 lb before permanent set.

From a paper entitled "Operational Stresses in Automotive Parts," presented at the SAE Annual Meeting in Detroit, January 8-12, 1951. Complete copies may be obtained from SAE, 29 W. 39th St., New York 18; $0.25 each to members, $0.50 to nonmembers.

Teamed for top performance



Walker-Turner 15" drill press (belt guard removed) showing Gilmer V-Belt Drive and the stepped sheaves which permit five speeds — 600 to 5,000 RPM.

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"MACHINES built with the *user's* special needs in mind!" That well-known Walker-Turner phrase means the *right design* for the job . . . right in every way from motor, through transmission, to the cutting tool. And not the least is dependable power transmission, a job that's being performed with top efficiency by Gilmer V-Belt Drives.

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Gilmer BELTS

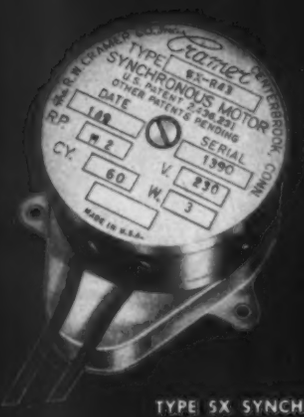
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timing
motors



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News
OF MANUFACTURERS

Snap-Tite Inc., manufacturer of swivel ball-bearing quick disconnected couplers, has moved to a larger plant at 201 Titusville Rd., Union City, Pa. The new plant contains modern facilities with which to meet customers' needs and will provide for increased production and the development of couplers for uses in new fields.

♦

Steel Improvement & Forge Co. of Cleveland has organized a wholly owned Canadian subsidiary, to be known as Canadian Steel Improvement Ltd. The new organization will build a plant in Toronto to forge turbine and compressor blades for jet propulsion engines for **A. V. Roe of Canada Ltd.,** who is building planes for the Dominion Government. To be completed this year, the new plant will have 41,000 sq ft of floor space and will employ at the outset approximately 180 workers.

♦

Cannon Electric Co. recently opened a new plant at 191 Kimberly St. on Highway No. 1, in the East Haven district of New Haven, Conn. This expansion will provide engineering and design consultation services for eastern customers at present, and as soon as possible warehousing, assembly, subcontracting and eventually manufacture will be added in order to give overnight delivery to the East Coast.

♦

Cleveland Vibrator Co., 2762 Clinton Ave., Cleveland, O., producers of air vibration equipment for over 25 years, has recently completed another addition to its plant. The new addition will house new automatic screw machines being used for vibrator production.

♦

Proportioneers, Inc., Providence, R. I., manufacturer of chemical proportioning and feeding equipment, has acquired Synchro-Master Co., formerly of Seneca Falls, N. Y. The business will be operated as the Synchro-Master Division, with sales and production facilities located in Providence. The merger makes available to Proportioneers, Inc. a proved mechanical differential and the background of experience in its applica-

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Dept. O-61 100 Reade St. New York 13, N. Y.

☐ Please send me information on Bruning BW machines.

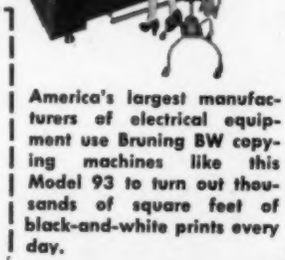
☐ I would like to see a Bruning BW machine demonstrated.

Name_____ Title_____

Company_____

Street_____

City_____ Zone_____ State_____



America's largest manufacturers of electrical equipment use Bruning BW copying machines like this Model 93 to turn out thousands of square feet of black-and-white prints every day.

tion in many fields. New designs are contemplated for use with the company's automatic proportioning and blending systems.

♦

Celanese Corp. of America has announced plans for the construction of a modern chemical plant located at Pampa, Texas, in the Panhandle area. The materials to be produced are used in the manufacture of yarns and plastics, synthetic rubber, explosives, and many other products. The plant will provide an additional source of the raw materials necessary to meet the increasing demand for the company's products and will also broaden the supply of chemicals for an accelerated defense program.

♦

Reading Crane & Hoist Corp. is the new name for Reading Chain & Block Corp., Reading, Pa. The change of name does not affect the capital structure, personnel, ownership or production of the company, but is merely more descriptive of the company's operation.

♦

General Electric Co. recently opened its new $2,000,000 measurements laboratory of the meter and instrument divisions at Lynn, Mass. The laboratory's corps of specialists conducts research into new ways to measure, develops new materials and devices, tests them for reliability and accuracy, evaluates manufacturing processes, maintains accuracy standards, and checks products off the production lines.

♦

Worthington Pump & Machinery Corp., Harrison, N. J., has acquired the land, buildings and equipment of National Transit Pump and Machine Co., Oil City, Pa. The plant, covering about 500,000 sq ft, will be utilized by the corporation for increasing its production of equipment related to national defense.

♦

Reynolds Metals Co. has awarded the contract for the construction of its $80,000,000 aluminum reduction plant in Texas to Henry C. Beck Co., Dallas, Tex.

♦

Consolidated Vultee Aircraft Corp., under contract to the U. S. Navy Bureau of Ordnance, has activated a new division—Missile Division. This will be the first integrated production plant for supersonic guided missiles in the country. The missile unit initially will occupy approximately 200,000 sq ft of floor space. It will be

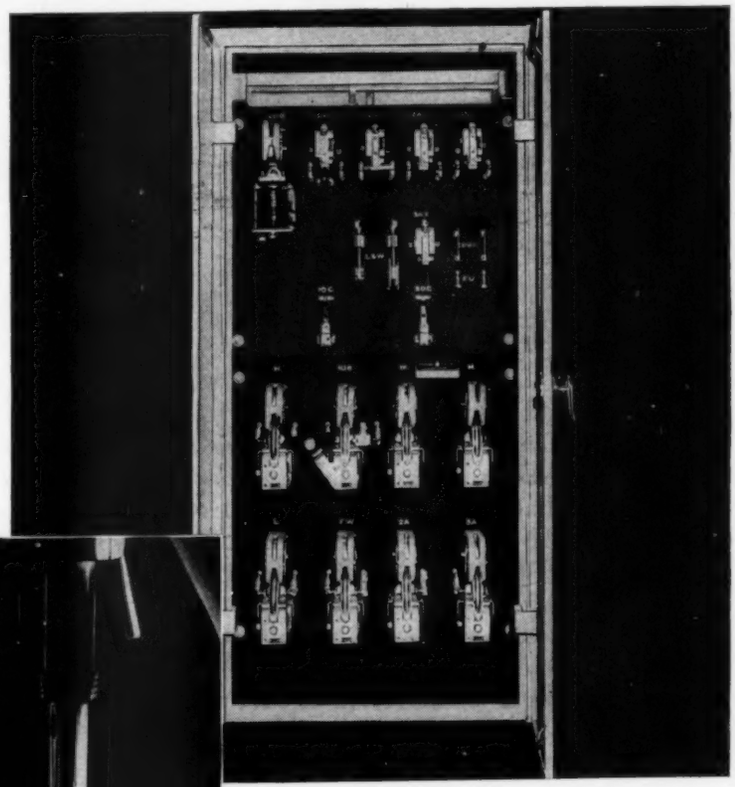
LAMINATES News

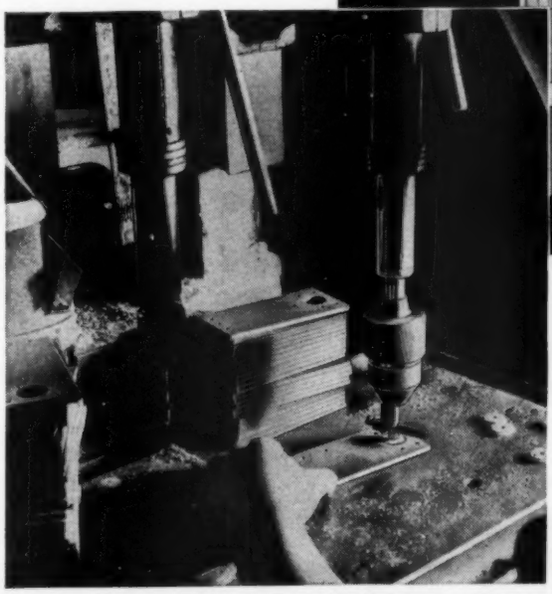
News of General Electric Plastics Laminates that can be of importance to *your* business.

G-E PLASTICS LAMINATES Give You EXTRA QUALITY AT LOW COST!

The engineering and manufacturing experience gained through many years in both the production and use of plastics laminates by General Electric is your assurance of extra quality at low cost.

For example, General Electric is one of the world's largest producers of naval and industrial control panels for both electrical and electronics applications. Through extensive work with this equipment, G.E. has developed a complete, high-quality line of laminated sheets for a wide variety of industrial and military applications.





FAST WORK!

With G-E Laminates, most high-speed machining operations are easily performed on standard wood and metal-working tools. Intricate shapes and fine cross sections can be machined to close tolerances with a minimum of rejects. Work can usually be performed dry, for easier handling of finished pieces.

NEW! LAMINATES COMPARATOR

Send ten cents for the new G-E Laminates Comparator—a quick, easy reference to different grades, characteristics and uses of laminated materials. Write Section Y-3, Chemical Department, General Electric Co., Pittsfield, Mass. Also, ask for information on the complete line of G-E Plastics Laminates.

COMPLETE LINE OF LAMINATES—General Electric produces a complete line of plastics laminates—either molded or in the forms of sheets, tubes and rods with cloth, paper, glass fabric, or special bases for a wide variety of applications.

ALSO—Look to General Electric for silicone insulation, insulating varnishes, sealing and filling compounds, mica insulation, varnished cloth and tape.

You can put your confidence in

GENERAL ELECTRIC



Design Them Around PERMACLAD *Stainless Clad Steel*

Today you can improve your products and equipment and give them corrosion resistance by designing them around PERMACLAD Stainless Clad Steel. PERMACLAD is stainless steel (usually 10% or 20% but can be varied to meet design requirements) inseparably welded to mild carbon steel. It has the surface characteristics of stainless steel and the easy forming qualities of mild carbon steel. With PERMACLAD it is possible to minimize use of critical materials and, at the same time, improve your product and give it corrosion resistance where corrosion resistance is needed. New applications for PERMACLAD are constantly being discovered. It will pay you to investigate and learn if your product or equipment can be improved with PERMACLAD. Write for complete information and a free copy of folder D-98.





For Better Products At Low Cost . . . Specify PERMACLAD

PERMACLAD
STAINLESS CLAD STEEL

ALAN WOOD STEEL COMPANY
CONSHOHOCKEN, PA.

125 Years of Iron and Steel Making Experience

Other Products: A. W. ALGRIP Abrasive Floor Plate • A. W. SUPER-DIAMOND Floor Plate • Plates • Sheets • Strip • (Alloy and Special Grades)

completely self-contained, with its own machine and other shops, industrial relations section, engineering department and assembly facilities.

♦

The Aluminum Co. of America has announced plans for a new aluminum smelting plant at Wenatchee, Wash. The new plant will supply 170,000,000 pounds of aluminum annually for defense and civilian needs. Construction will begin immediately, and it is hoped that the first aluminum can be produced at the plant within 15 months.

♦

Keystone Carbon Co., Saint Marys, Pa., has completed an addition of 20,000 sq ft of floor space for the manufacture of powder metal parts and negative temperature coefficient resistors.

♦

Servomechanisms Inc. formerly at Old Country and Glenn Cove Roads, Mineola, N. Y., has moved its main office and home plant to new and larger quarters at Post and Stewart Avenues, Westbury, N. Y. Situated on a two-acre plot, the plant contains a total available floor area of 36,000 sq ft, with 30,000 sq ft allocated to engineering and production, and the remainder to general office.

♦

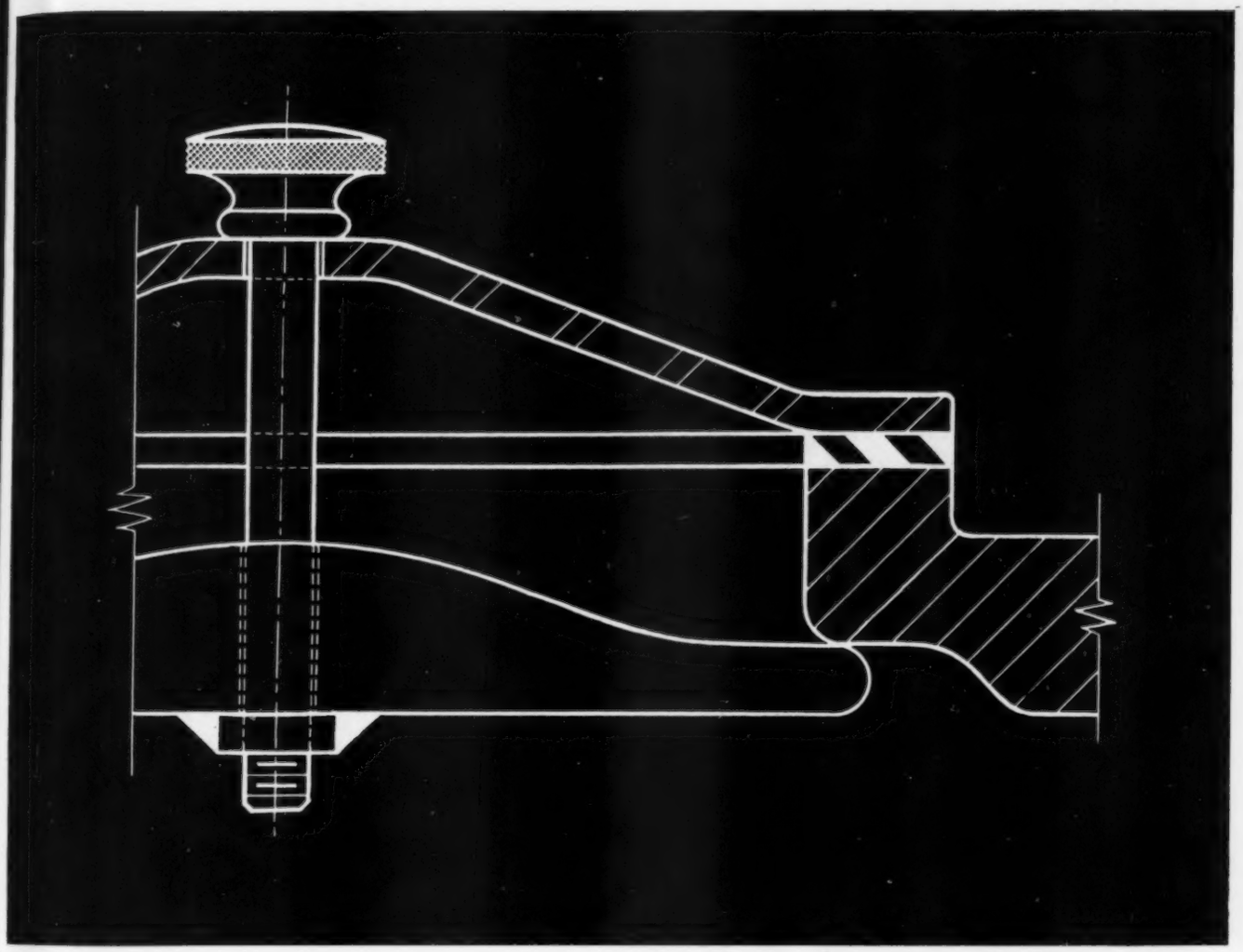
The E. I. du Pont de Nemours and Co. Inc. new experimental station addition was dedicated May 10 before an assembly of some 200 distinguished academic and industrial scientists. This experimental station represents a $30,000,000 investment.

♦

The Sprague Electric Co. has purchased part of the main plant of the former Holden-Leonard woolen mill in Bennington, Vt., to expand its facilities for the manufacture of high-temperature magnet wire. The new Sprague plant contains some 45,000 sq ft of floor space, which will be devoted solely to the manufacture of Ceroc 200 and Ceroc T magnet wire for military electronic and electrical components.

♦

Sharon Steel Corp. has officially named the company's operating facilities at Farrell, Pa., the "Roemer Works". The plant was named in honor of Henry A. Roemer, veteran steel leader who is chief executive officer of the company and chairman of its board of directors. The action was taken to commemorate Mr. Roemer's twenty years of leadership of the company, and was accompanied



Military applications for cork-and-rubber gaskets

Here are answers to a few of the questions design engineers are asking us about military applications of cork-and-rubber gasket compositions.

Where is cork-and-rubber most useful in military applications?

Cork-and-rubber is used effectively to seal: (1) metal-to-metal joints, (2) stamped and rough cast parts, (3) joints which will be repeatedly opened and resealed in the field, and (4) in any application where it is desirable or necessary to combine the compressible and frictional qualities of cork with the solvent and weather resistant qualities of synthetic rubber.

Can cork-and-rubber be used in equipment intended for low-temperature operations?

Yes. Most standard compounds may be used at temperatures as low as −40° F. Special compounds may be necessary for use at lower operating temperatures.

Is it possible to replace another gasket material with cork-and-rubber and thus cut production time?

Yes. In a metal-to-metal joint, for example, flange faces are finished to the tolerances demanded by the assembly. The gasket and gasket channel, however, need not be held to close tolerances if a compressible gasket is used. A slightly oversized cork-and-rubber seal, square or rectangular in cross-section, distorts to the shape of the channel, compresses fully, and allows perfect mating of the flanges. It eliminates the need for either a relief for side-flow or its alternative, a molded gasket.

How well does cork-and-rubber resist fatigue?

Armstrong's Cork-and-Rubber Compositions have excellent resistance to fatigue. This, combined with their reduced tendency to cold flow, makes them ideal for applications in which joints are subject to frequent opening and resealing in the field.

How effective is cork-and-rubber in sealing stampings?

In the drawing above, a cork-and-rubber gasket is used to seal a stamped diesel hand hole cover. The composition compresses easily into the irregularities of the stamping. At the same time, it is impervious and sufficiently resilient to form an effective seal under light bolt pressures.

There is an Armstrong Composition designed to meet each of the six grades in MIL-G-6183 (formerly AN-G-32) covering cork-and-rubber gasketing materials. In addition, Armstrong's research laboratories are ready to develop new cork-and-rubber materials for applications for which no suitable material may be available.

For further information on Armstrong's Cork-and-Rubber Compositions and their application, call your Armstrong representative or refer to Armstrong's Gasket Materials Manual in Sweet's file for product designers. For a personal copy of this manual, write to the Armstrong Cork Company, Gaskets and Packings Department, 5106 Arch St., Lancaster, Pa.

ARMSTRONG'S *Gasket Materials*



PERFECTED TAPER makes the difference in American Wedgbelt Sheaves!

A few turns of just three set-screws and any American Taper-Bushed Wedgbelt Sheave is INSTANTLY TIGHT or QUICKLY RELEASED. This means easier, faster assembly of your product.

American "perfected-taper" Sheaves and American Wedgbelts combine for perfected performance!

• Quiet • Vibration-Free • Long-Wearing Grooves
• Maximum Pulling Power • Minimum Belt Stretch
• Long Belt Life.

MAIL TODAY!

AMERICAN WEDGBELT DRIVES

Perfected Taper Makes The Difference

The American Pulley Company 4238 Wissahickon Ave., Phila. 29, Pa.

At no obligation, please send me complete information on American Wedgbelt Drives.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

by a testimonial and gift presented by associates in the company. Under Mr. Roemer, the Sharon production capacity has increased from 560,000 to 1,400,000 ingot tons per year, and coal and coke properties have been added to integrate the company.

♦

Carboloy Co. Inc., Detroit, has initiated a broad service program of furnishing vital technical production data to defense industries. The move will enable such industries to obtain maximum productivity with minimum tooling in the manufacture of products for the armed services.

♦

Allis-Chalmers Mfg. Co. is erecting a new 80 by 210-ft nonferrous foundry building at its Norwood, O., works, which is expected to be in operation early this fall.

♦

The **Sebastian Lathe Co.** of Cincinnati, was acquired recently by **Cincinnati Metalcrafts Inc.** The assets and tradename of the lathe company were sold by American Steel Foundries, the former owner, who retained the plant and manufacturing facilities. The newly acquired company will be known as the Sebastian Lathe Division, Cincinnati Metalcrafts Inc. Manufacturing and administrative operations have been moved to the modern plant of Cincinnati Metalcrafts Inc., 5000 Brotherton Road, Cincinnati, O. New production machine tools have been added to existing facilities, and production schedules will be stepped up to meet increasing defense demands for machine tools of this type.

♦

The **Hardinge Co., Inc.,** New York, owner of **Hardinge Manufacturing Co.** of York, Pa., has entered into a contract with the **Meehanite Metal Corp.,** New Rochelle, N. Y. to produce Meehanite castings in its foundry at York, Pa.

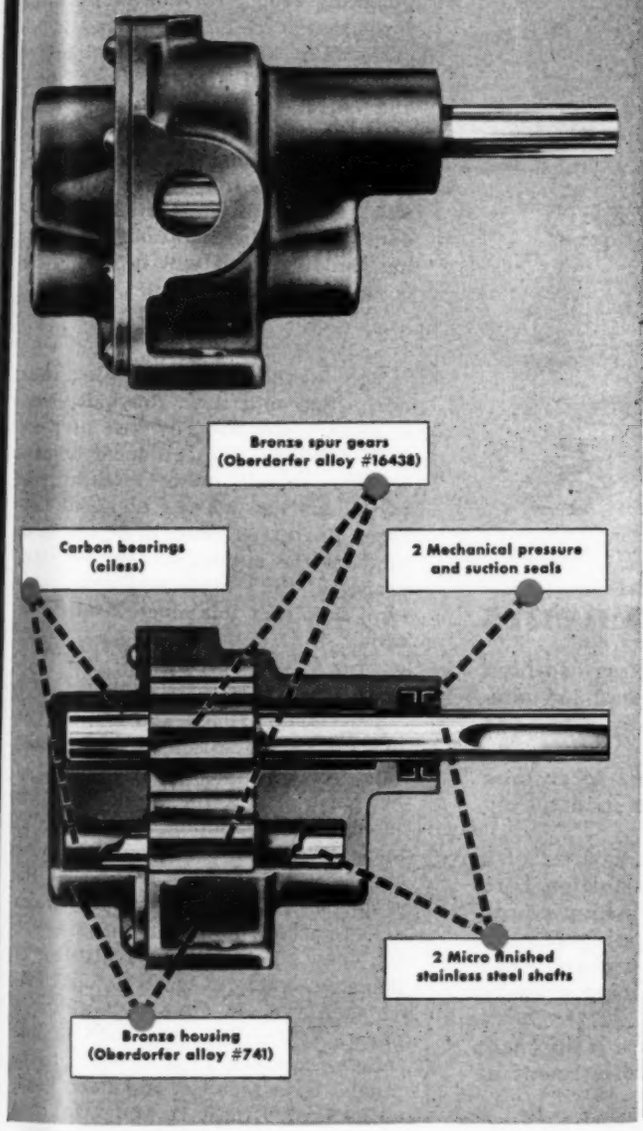
♦

Westinghouse Electric Corp. has announced formation of a new Air-Arm Division and plans for a new plant in Baltimore, to build equipment advancing aerial warfare "a step closer to the pushbutton stage." The company has purchased 75 acres on a corner of the Baltimore Friendship Airport. There, by the end of the year, the company will be producing for the Navy and Air Force automatic computers to direct gun and rocket fire, radar and autopilots for fighter planes and guided missiles, and complete airborne armament systems. The company has also an-

Since the six OBERDORFER INTERNATIONAL pumps described below are new, with no prior history of use, Washington expects a DEFENSE ORDER or equivalent for their purchase. Free samples are available to O.E.M. accounts.

5 Major Points of Superiority in the New Series 1* ...

OBERDORFER INTERNATIONAL BRONZE ROTARY GEAR PUMPS



These precision built pumps have been specifically designed for long and economical industrial service, and to reduce liquid transfer costs in the vast variety of applications where they are suitable. Their five major points of superiority incorporate all the engineering and production knowledge amassed in building literally millions of bronze pumps over a period of more than 50 years. These new Series 1 OBERDORFER INTERNATIONAL pumps will prove their worth in intensive, on-the-job tests against any competitive pumps on the market today.

CAPACITY TABLES

Gallons of Water Per Hour for Series 1 OBERDORFER INTERNATIONAL PUMPS Outlet Pressure—P.S.I. (Pounds per square inch)

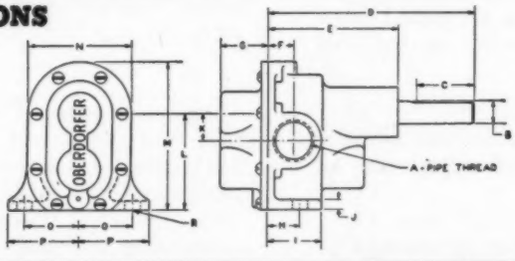
1725 RPM (Standard Electric Motor Speed)						
Pump Size	2 lbs.	20 lbs.	40 lbs.	60 lbs.	80 lbs.	100 lbs.
No. 1½	126	115	105	98	93	90
No. 2	245	225	215	205	195	190
No. 3	445	425	405	390	380	370
No. 4	640	610	580	550	530	510
No. 7	1185	1160	1140	1120	1100	1085
No. 9	1400	1375	1350	1325	1300	1280

PRICE LIST

Oberdorfer International Series 1
IMPORTANT: Order by Part Number

1½	2	3	4	7	9
Part No. 1000	Part No. 2000	Part No. 3000	Part No. 4000	Part No. 7000	Part No. 9000
$14.25	$15.75	$20.00	$22.25	$28.50	29.75

DIMENSIONS



Pump Size	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
1½	¼	½	1	3 11/16	2 3/16	3/16	1 3/16	3/16	1 1/16	3/16	11/32	1 7/16	2 7/16	1 13/16	7/16	1 1/4	3/16
2	1/4	1/2	1	3 11/16	2 3/16	11/32	1 1/4	3/16	1 3/16	1/4	11/32	2 3/16	3 3/16	2 3/16	1 1/16	1 3/4	3/16
3	1/2	3/8	1 1/2	4 11/16	3	11/32	1 1/4	3/4	1 1/2	1/4	3/8	2 5/8	4	2 3/4	1 3/16	1 1/2	11/32
4	1/2	3/8	1 1/2	5 3/16	3 3/16	13/32	1 1/2	7/8	1 13/16	1/4	3/8	2 5/8	4	2 3/4	1 3/16	1 1/2	11/32
7	3/4	3/8	1 1/2	5 3/16	3 3/16	3/4	1 1/2	7/8	1 13/16	5/16	1	3 3/16	5 1/4	3 3/4	1 1/16	2 1/16	11/32
9	1	3/8	1 3/4	5 3/16	3 3/16	3/8	1 1/4	7/8	1 11/16	5/16	1	3 3/16	5 1/4	3 3/4	1 1/16	2 1/16	11/32

FACTS ABOUT OBERDORFER

1. The third largest non-ferrous foundry in the U. S.
2. Over a half century of bronze pump manufacturing experience
3. Long-established world-wide pump distribution
4. Millions of pumps in service
5. Capitalization over one million dollars
6. 1951 capacity for 250,000 Series 1 OBERDORFER INTERNATIONAL pumps

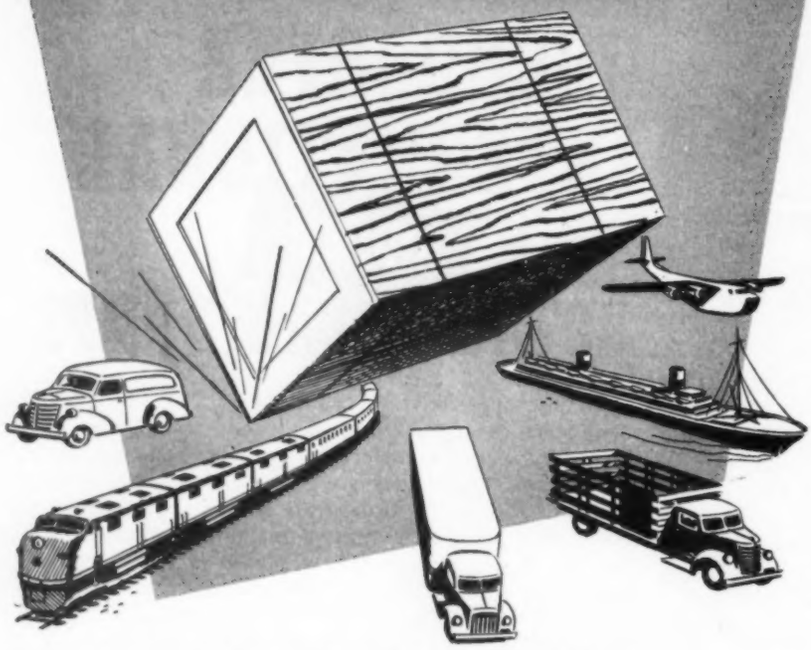
* First of five new series

Write Dept. MD516

INDUSTRIAL PUMP DIVISION
Oberdorfer Foundries, Inc.
Syracuse, N. Y.

A Revolutionary Development!

LORD Shipping Mounts



Provide New Safety for Shipments

Lord Shockproof Packing does away with solid bolting, cushion packing, and all other methods heretofore used in the attempt to safeguard the shipment of fragile products, sensitive equipment, and complicated mechanisms.

The product rides on Lord Shipping Mounts, designed to cushion the forces of shock in transit. Even under severe abuse in handling *the product never touches the container.*

From the knowledge and experience gained in over a quarter of a century of specialization in solving shock and vibration problems, Lord has developed flexible rubber mountings to adequately cushion equipment against shock forces from all directions. Lord Shipping Mounts are easily installed in your own shipping cases by your packers. They are accurately designed for correct resiliency and load bearing strength to protect *your* product.

Users report: "No breakage on record" . . . "Haven't lost a shipment due to rough handling" . . . "Need for servicing and adjustment of machines on arrival practically eliminated."

The LORD representative in your area will recommend the type, number, and placement of Lord Shipping Mounts to safeguard your shipments. Call the nearest Lord Field Office, or write us for full information.

LORD SHIPPING MOUNTS

- Provide positive shock protection.
- Permit shipping completely assembled product.
- Reduce need for servicing and adjustment at destination.
- Eliminate packing errors . . . save time.
- Reduce fire hazard by eliminating storage of loose packing materials.

LORD MANUFACTURING COMPANY • ERIE, PA.

Canadian Representative: Railway & Power Engineering Corp. Ltd.

LORD BONDED RUBBER

Vibration-Control Mountings . . . Bonded-Rubber Parts

nounced plans for construction of an electronic tube manufacturing plant on a 70-acre site in Bath, N. Y. This plant will produce electronic tubes for the Armed Services and for essential industries.

♦

B. F. Goodrich Co. has greatly expanded the production of DeIcers, the pulsating rubber tubes which prevent formation of ice on the wings and tail surfaces of airplanes. Several thousand additional feet of floor space and extra equipment are now being used for this purpose. Also, construction of additional facilities for the company's Research Center in Brecksville, O., has been started. The expansion includes additions to existing buildings and will be ready for occupancy in October.

♦

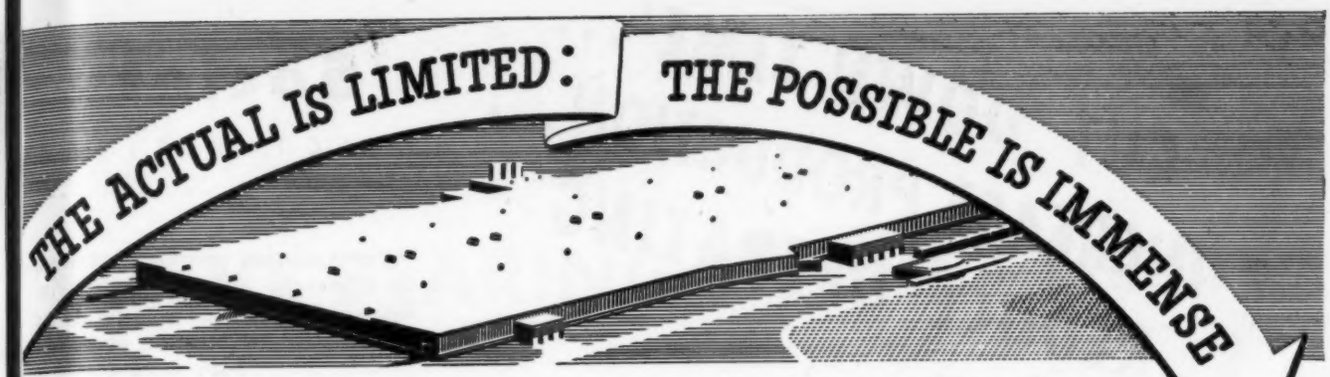
The **Nevada Scheelite Co.**, with mines and mill near Rawhide, Nev., is being transferred by sale of stock to **Kennametal Inc.**, producer of hard carbide metals with metallurgical works and tool making shops at Latrobe, Pa. Steps have been taken to improve the output of this tungsten property, thus increasing the country's supply of this much needed material.

♦

The **Silent Hoist and Crane Co.**, Brooklyn, has established a $5,000 trust fund for the annual award of two cash prizes for student papers on materials handling. The object of these awards is to encourage young engineers to try to solve one of the problems of modern industry which adds to production costs. Income from the new Polytechnic Institute of Brooklyn trust fund will be distributed each year in June to authors of papers of merit in the field of materials handling. Papers are to be judged by a faculty committee headed by Prof. Ernest L. Midgette, head of the Department of Mechanical Engineering.

♦

Paper Machinery and Research Inc., 1014 Oak Street, Roselle, N. J., has expanded its facilities for the production of engraved applicator rolls. Pamarco engraved applicator rolls include Evenflo inking rolls and rolls for applying plastics, adhesives, color and other materials in liquid form. New improved production facilities include a larger stock of dies and die sizes, new precision engraving machines, and other modern shop equipment that assures greater precision and faster delivery of applicator rolls for every use.



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

© LE Co. 1951

FLEXIBILITY IN MANUFACTURE MEANS LOWEST COST PER PIECE

Products designed to utilize the economies of welded steel can be manufactured at lower cost regardless of quantity produced. Any product design can be developed from an unlimited combination of steel shapes to suit the type of manufacturing equipment available.

Each of the tee sections shown has been designed to withstand equivalent loads. As quantities of production increase and brakes, shears and forming equipment become advisable, less material is, of course, required and the amount of welding itself can be reduced.

Your Lincoln Welding Engineer will gladly explain how your products can be simplified and fabricated at lower cost using welded steel construction. Simply write The Lincoln Electric Company, Cleveland 1, Ohio.



Fig. 5. For higher quantity production, *tee can be brake formed as a single piece from sheet and automatically Lincolnwelded at top. Weighs 30% less than Figure 1 . . . costs 40% less.*

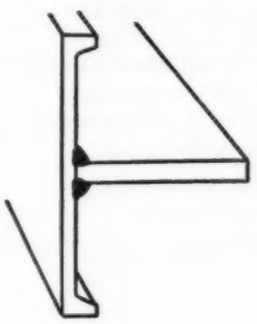


Fig. 4. Tee section *fabricated from light channel is automatic Lincolnwelded to plate cut to shape by high speed equipment. Gives better material distribution. Costs 35% less than Fig. 1.*



Fig. 3. Angles, brake formed *from plate, have better dimensions to withstand loading. Section requires only light, intermittent welds. Costs 30% less than Figure 1.*

the ACTUAL

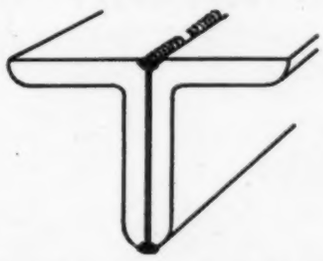


Fig. 1. Tee section *fabricated in small lots by welding standard angles back to back. Requires only hack saw and welder.*

increasing the YIELD

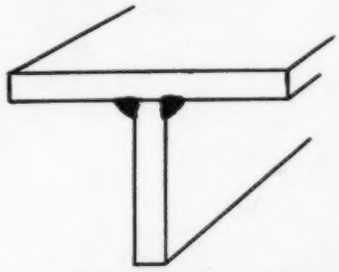


Fig. 2. Tee section *for medium quantity lots for the shop having shear or flame cutting equipment. Costs 25% less than Figure 1.*

the IMMENSITY of the POSSIBLE

Economical production regardless of quantity

SEE HOW WELDED STEEL IS FABRICATED AT LOW COST

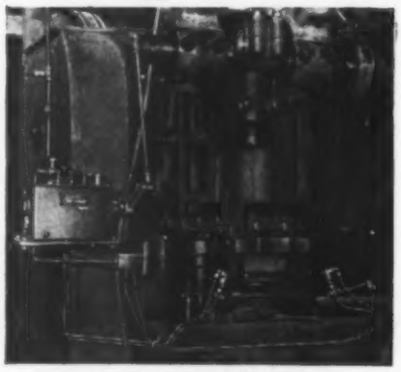
Machine Design Sheets free on request to designers and engineers. Write on your letterhead to Dept. 16

THE LINCOLN ELECTRIC COMPANY

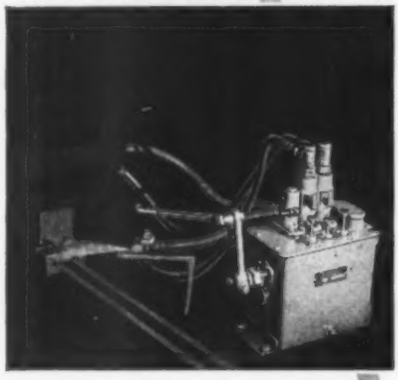
CLEVELAND 1, OHIO

CUT 'DOWN TIME'... INCREASE PRODUCTION... REDUCE OPERATING COSTS...

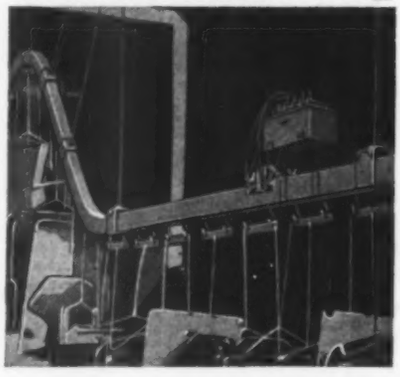
IN PRESS OPERATIONS



IN SHEAR OPERATIONS



IN CONVEYOR SYSTEMS



Dies, punches, and shear knives wear up to three times as long! Only 1/10 as much oil now being consumed! Punch breakage reduced, oil drippage eliminated! . . . These are typical comments of manufacturers using the new Manzel Automatic Spray System. And in every case the savings are out of all proportion to the modest cost of installing the system.

Manzel Spray Lubricators force automatically timed jets of oil spray directly onto the punches, shear knives, dies, rollers, or other parts. Compressed air and oil are fed simultaneously into a spray nozzle aimed at the critical area. The system is readily installed on any type of equipment, large or small. Write today for descriptive folder.

Manzel engineers will gladly assist you in solving any lubrication problems.

WITH MANZEL SPRAY LUBRICATION

Manzel

DIVISION OF

FRONTIER INDUSTRIES, *Inc.*

276 BABCOCK STREET, BUFFALO 10, N. Y.

Society

ACTIVITIES

The **American Institute of Electrical Engineers** will present the 1950 Benjamin G. Lamme gold medal during the General Meeting at Toronto, Canada, June 25-29. Recipient of the award will be Donald I. Bohn, chief electrical engineer of the Aluminum Co. of America. Bohn represents the 22nd recipient of the medal which is awarded annually to an Institute member "who has shown meritorious achievement in the development of electrical apparatus or machinery."

•

The SAMA Award for Outstanding Service, presented only twice since the **Scientific Apparatus Makers Association** was established 33 years ago, was given recently to Col. Evan E. Kimble, pioneer leader in the field of machine and handmade glassware and founder of Kimble Glass Co., now a division of Owens-Illinois Glass Co.

•

New models of materials handling equipment valued at an estimated $10,000,000 were on display at the National Materials Handling Exposition in Chicago from April 30 through May 4. This exposition is sponsored by the **Material Handling Institute.** Thousands of new models were displayed by 240 companies in exhibits spread over eight acres, and for the first time an outdoor exhibit area was provided for demonstrations of handling machinery for bulk and liquid materials.

•

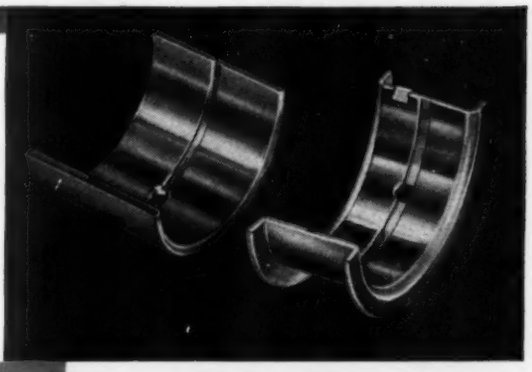
Setting a new attendance record, 2074 members and guests of **The American Ceramic Society** recently met in Chicago for the fifty-third Annual Meeting of the Society. Howard R. Lillie, research physicist for Corning Glass Works, Corning, N. Y., was installed as president for 1951-52. Serving with him the coming year will be president-elect William E. Cramer, president of Industrial Ceramic Products Inc., Columbus, O.; vice presidents Probert W. Dager, sales engineer for the H. C. Spinks Co., Van Nuys, Calif., Ray W. Pafford, vice president and general plant manager of the Acme Brick Co., Fort Worth, Tex., and Arthur A. Wells, vice president and general superintendent of the Homer Laughlin China Co., Newell, W. Va.; treasurer Edwin M. Rupp of Columbus, O.,

...to Get the Most in Your SLEEVE BEARING APPLICATIONS

Simplified design and production savings can be effected in bearings, bushings and similar precision parts by designing the bearing when the engine or unit itself is designed. Re-design of bearings alone can sometimes be very helpful also. Our Engineering Department is prepared to provide this service—consult us without obligation.

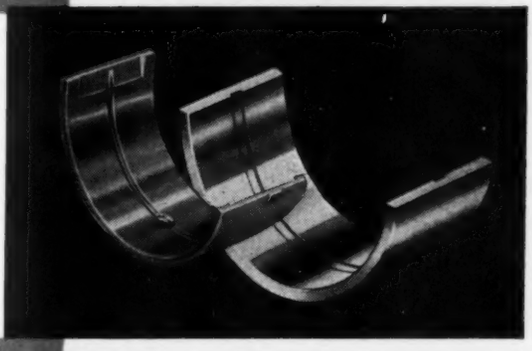
LEAD BASE OR TIN BASE LINING

Many alloy variations are available. When design, alloy lining, back material and production method are properly combined, you obtain maximum performance at a practical cost.



CAST OR SINTERED COPPER-LEAD

Copper-leads of similar chemical analysis can give radically different performance results. Our improved copper-lead metal powder and entirely new casting techniques for our cast bearings permit great flexibility to meet the widest range of requirements.



CAST OR ROLLED SPLIT-TYPE BUSHINGS

For heavy-duty service we produce cast bronze bushings (and intricate precision bronze parts) to almost all bronze specifications. The rolled split-type bushing offers many economies where heavy-duty is not involved, provides substantial material savings while maintaining performance standards.



FREE

ENGINEERING SERVICE

Our Engineering Department is glad to work with you in original design development or re-design of existing units.

For information address:

FEDERAL-MOGUL

Since 1899

Our six plants produce sleeve bearings in all designs and sizes; cast bronze bushings; rolled split-type bushings; bi-metallic rolled bushings; washers; spacer tubes; precision bronze parts and bronze bars.

FEDERAL-MOGUL CORPORATION, 11045 Shoemaker, Detroit 13, Michigan

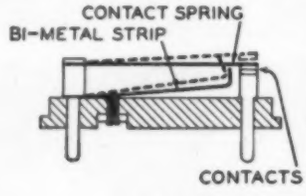


CHACE BIMETAL
Keeps Them Home on the Range!

Stevens Type "C" Thermostat (shown full size) Manufactured by Stevens Mfg. Co. Mansfield, Ohio (Patent applied for)

TELEVISION plays a big part in keeping the "small fry" at home these days, and this Stevens Type C thermostat helps keep their favorite programs on the video screen. Actuated by Chace Thermostatic Bimetal, the thermostat is used in communications equipment, electronic devices and other apparatus requiring a high degree of temperature stability.

In its television and radio application this thermostat maintains a constant ambient temperature around the quartz crystals which control transmitter frequencies; this prevents variation in these frequencies. Since it is essential that the thermostat respond only to the temperature of the device it controls, an *electrically independent* strip of Chace Thermostatic Bimetal forms the actuating element. Current flows through the stainless steel or alloy spring, but does not pass through the thermostatic bimetal. As the bimetal element responds to a predetermined ambient temperature it overcomes the spring pressure and opens the contacts. This assures a sharp, clean break and eliminates artificial cycling or life-shortening "jitters."



The simplicity, efficiency and compactness possible when using Chace Thermostatic Bimetal enables Stevens to furnish this thermostat in a wide variety of production models, each using the same actuating element. Perhaps *your* product, too, can offer extra advantages when designed around an actuating element of this versatile material. Let The Chace Application Engineer, with his background and experience in the control of temperature-responsive devices by Chace Thermostatic Bimetal, help you.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

sales engineer representing the United Feldspar and Minerals Corp. and National Engineering Co.; and general secretary Charles S. Pearce of the Society's headquarters in Columbus, O. Dr. Ralph K. Hursh, a member of the University of Illinois faculty at Urbana since 1911, received the Society's highest award, the Ross Coffin Purdy Award, which is given annually for "the most valuable contribution to ceramic technical literature."

♦

Senator Ralph E. Flanders of Vermont was awarded an honorary membership in the **American Society of Tool Engineers** during the Annual Meeting of the Society in New York.

♦

More than 300 manufacturers, representing both small and big business in the Midwest and the East, met with representatives of the Armed Forces on May 17 and 18 in Detroit to discuss mass production for defense and the problems arising from a "peace or war" economy. The conference was called by the **National Security Industrial Association,** a nonlobbying, nonprofit organization which functioned efficiently during World War II as a close tie between producers and the military. Co-operating as hosts to the visitors were General Motors Corp., Chrysler Corp., the Ford Motor Co. and the Jam Handy Organization, each of which had arranged presentations on particular operations applicable to the task of meeting defense demands while maintaining the civilian economy.

♦

The **American Society of Tool Engineers** have chartered two new chapters, the 87th and 88th. The new chapters are Jackson, Mich., and Long Island, N. Y.

♦

Formation of a joint committee representing the nation's foundries, scrap dealers and steel mills to deal with the critical scrap problem was announced recently by Robert W. Wolcott, chairman, Lukens Steel Co., and chairman of the Committee on Iron and Steel Scrap of the **American Iron and Steel Institute.** The new committee is to be called the Mobilization Committee for Iron and Steel Scrap.

♦

Thomas Robins Jr., president of Hewitt-Robins Inc. and president of the newly reactivated Kentucky Synthetic Rubber Corp., Louisville, Ky., has been elected a director of the **Rubber Manufacturers Association.**

FOR PORTABLE EQUIPMENT...

Caravan Axles



DESIGN MEN SPECIFY CARAVAN axles because they increase operating efficiency, provide dependable movability and reduce axle costs.

CARAVAN AXLES are recommended for utilization with military and industrial as well as field service and construction equipment such as concrete mixers, welding apparatus, drilling rigs, fire fighting apparatus, etc.

CARAVAN units can be furnished in two-wheel, single-axle assemblies as well as four wheel running gear equipped with automotive type steering mechanisms. Straight and drop-axle type construction can be supplied as standard.

Employing controlled camber, toe-in and caster, which facilitate positive trail at high speeds, CARAVAN AXLES provide smooth steady movability over high grade surfaces and maximum roadability over rough terrain. Axle beam construction is of solid square steel stock and sized to individual specifications.

CARAVAN AXLES are available having load capacities ranging from 1000 to more than 12,000 pounds, and they can be furnished in a wide range of sizes and models to meet all requirements.

Write today for your copy of UNITED'S new 12-page, multi-colored and illustrated Catalog No. 101 which describes CARAVAN axles as well as CARAVAN surge-control braking device and CARAVAN retractable third-wheel for use with two-wheel single-axle units. Catalog includes photographs, line drawings and complete specifications.



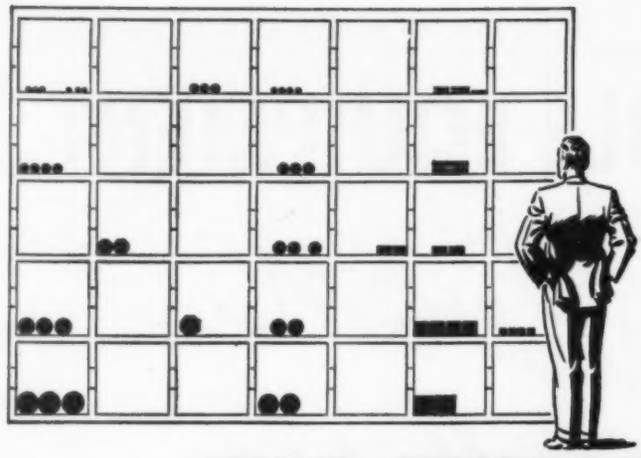
225-UM

THE UNITED MANUFACTURING CO.

14 West Interstate Street • Bedford, Ohio

OVER ONE HUNDRED YEARS OF CONTINUOUS SERVICE. ROUNDS, SQUARES, FLATS, HEXAGONS, OCTAGONS

BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS.



The present serious **STEEL SHORTAGE** has reduced our warehouse stocks of HY-TEN and Standard alloy steels to a sub-normal level.

This inventory situation is, of course, very unsatisfactory but we are doing everything we possibly can to improve it.

Our aim is to allocate available stocks to our customers in the fairest and most equitable way possible.

Defense certifications on your warehouse orders will aid us greatly in supplying your alloy steel needs.

In the light of current conditions, we suggest that you put our metallurgical knowledge and experience to work for you.

It frequently happens that, when certain exact specifications are not available, our metallurgists can recommend entirely suitable substitute materials or alternate methods of manufacture and treatment.

Your nearby Wheelock, Lovejoy representative knows metallurgy. He stands ready to give you expert assistance in solving your problems.

Write today for your **FREE COPY** of the Wheelock, Lovejoy Data Book, indicating your title and company identification. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.

133 Sidney St., Cambridge 39, Mass.
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Hillside, N. J. • Buffalo • Cincinnati



WHEELOCK, LOVEJOY & CO., INC.

Warehouse Service

CAMBRIDGE · CLEVELAND
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DETROIT · BUFFALO
CINCINNATI

In Canada
SANDERSON-NEWBOULD, LTD., MONTREAL

HY-TEN *and* **AISI**

SALES AND SERVICE

Personnel

FORMERLY assistant sales manager, **A. F. Reinking** has been named manager of the steam turbine sales division of Worthington Pump and Machinery Corp. He will make his headquarters at the company's Wellsville plant. Mr. Reinking completed the Worthington student training course in 1927 and was assigned to the New York district office. Two years later he joined the Moore Steam Turbine Corp., but again became associated with Worthington when that corporation purchased the Moore company in 1936.

♦

Formerly production manager for magnesium wrought products at Midland, Mich., **R. E. McNulty** has been named manager of the new Madison, Ill., division of The Dow Chemical Co.

♦

The Lenkurt Electric Co., San Carlos, Calif., has announced the appointment of **Edward G. Hall** as engineering representative for its sales and engineering service department. For several years before joining this company, Mr. Hall had been general transmission engineer for the Indiana Associated Telephone Corp., Lafayette, Ind.

♦

H. J. Lafaye has been named sales manager and **W. J. Lee**, assistant general manager in the rim division of the Goodyear Tire & Rubber Co.

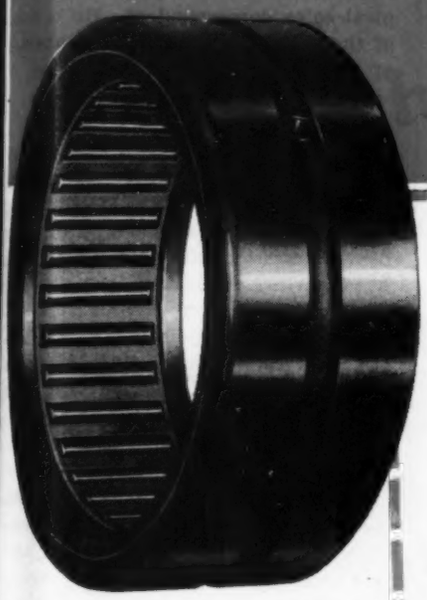
♦

The appointment of **Charles R. Schmitt** as manager, lubrication sales department, has been announced by E. F. Houghton & Co., Philadelphia. Formerly lubrication manager for the central and western division, Mr. Schmitt has been transferred to the company's main office in Philadelphia from Cleveland.

♦

The board of directors of the Erie Manufacturing Co., Erie, Pa., recently named **Earl C. Miller** executive assistant to **R. F. Merwin**, president, and promoted **M. L. Cramer** to sales engineer. Mr. Miller came to the company in March, 1948 as sales engineer and in June of the same year was

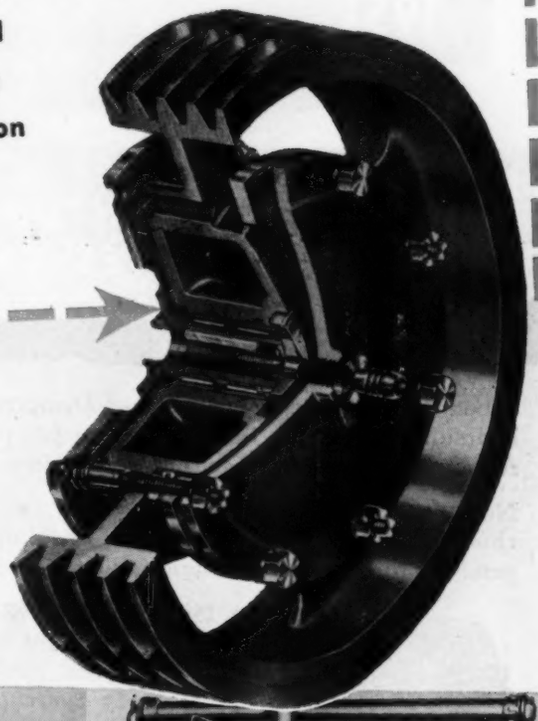
ORANGE *Cage Type* NEEDLE BEARINGS



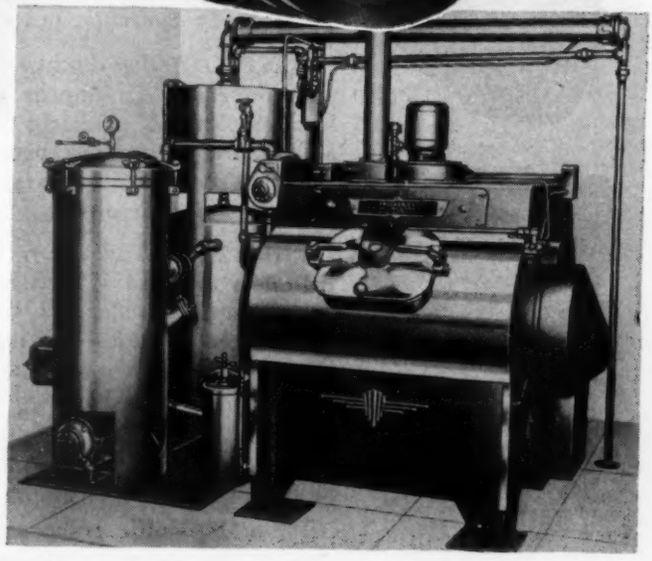
—used in Clutch Disc Sleeve of

PROSPERITY DRY CLEANING MACHINE

Close tolerances and rugged construction provide quiet operation and friction-free protection



• In Model 6A Prosperity Dry Cleaning Machines, the Pneumatic Diaphragm Clutch is engaged during the washing operation and disengaged during the extraction operation. At the shift, clutch locks the "V" pulley and power is transmitted through the keyed Extractor motor shaft. The clutch disc sleeve for this shaft is mounted on a double-row Orange Cage Type Needle Bearing with inner race to prevent linear creep. The Prosperity Co., Inc., Syracuse, N. Y., has been using these bearings for seven years, with highly satisfactory results.



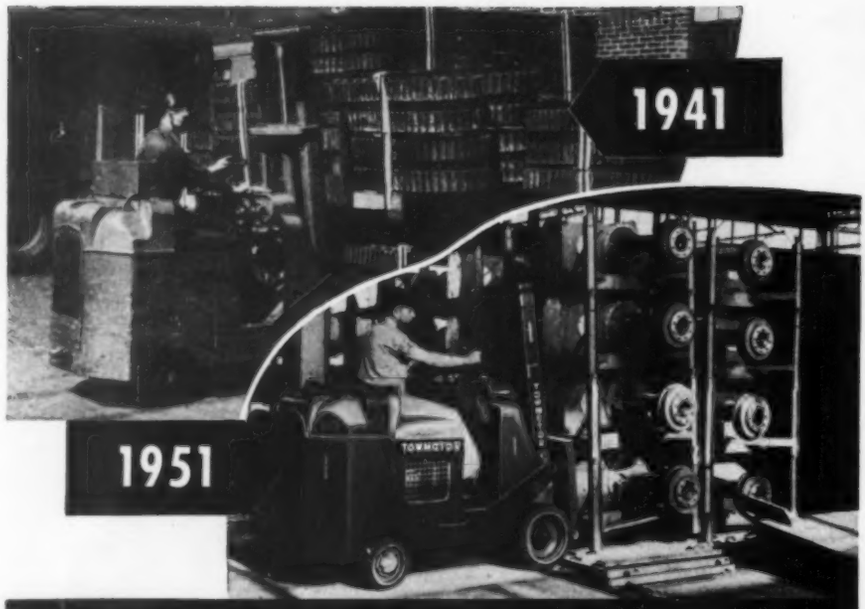
Exclusive cage design holds rollers in permanent alignment—prevents skewing—permits precision-controlled internal clearances.

Orange Cage Type Needle Bearings are serving with great success in spindles—vertical installations—overhung mountings and relatively high speed applications. They are less affected by misaligned mountings and uneven loadings. They are unequalled where extreme precision and quiet, smooth running are essential. Yet, with all these features, they provide high load-carrying capacity in limited space, plus a "bonus" of Pentrate-finished raceways and rollers for increased resistance to corrosion and friction.

WRITE FOR ENGINEERING DATA FOLDER on Cage Type Needle Bearings, showing construction, advantages, dimensions, capacities, etc.

ORANGE

ORANGE ROLLER BEARING CO., INC., 556 Main Street, Orange, N. J.



HYDRECO OIL HYDRAULIC
PUMPS • VALVES • CYLINDERS
once again help speed American Defense

When America was The Arsenal of Democracy, HYDRECO-equipped hydraulic lift trucks like the Towmotor pictured above, helped to revolutionize material handling in the new defense industries.

Now once again, HYDRECO-equipped industrial lift trucks, such as this '51 Model LT40 Towmotor, are "mass-handling" industrial products to help speed American defense.

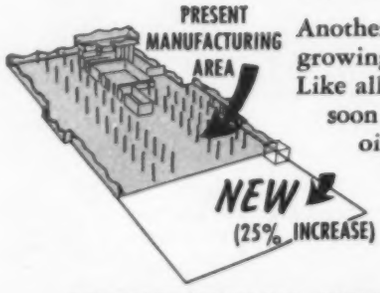


A 1500 Series HYDRECO gear pump, designed to operate at full engine speed, is directly coupled to the Towmotor engine to provide always-ready hydraulic power.

HYDRECO Hollow-Plunger control valves are used on these Towmotor trucks to cut out lost motion in picking up and stacking, as HYDRECO valves provide smooth and accurate control in raising, tilting, and accessory operations.



On the LT40 Towmotor, both tilt and lift cylinders are also HYDRECO-built. Designed for operation under all conditions, efficient wipers and cylinder packing *keep oil in and dirt out* of the hydraulic system.



Another new addition to HYDRECO's fast-growing plant is scheduled for completion soon. Like all HYDRECO facilities, this addition will soon be devoted entirely to the production of oil-hydraulic pumps, valves and cylinders for the materials handling, earth moving, road building and other equipment industries.

HYDRAULIC EQUIPMENT COMPANY
1106 EAST 222nd STREET • CLEVELAND 17, OHIO

promoted to export sales manager. Mr. Cramer first became associated with Eriez in January, 1949 as technical sales correspondent. He is head of the sales department in the absence of **R. A. Roosevelt,** sales manager.

♦

The H. M. Harper Co., Morton Grove, Ill., manufacturer of nonferrous and stainless steel fastenings, has appointed **Ralph N. Hillner** as central district sales manager. With headquarters at Morton Grove, he will now supervise nine regional offices. Until his new appointment, Mr. Hillner was manager of the company's St. Louis office, a position which has been filled by **Glenn N. Hunolt.**

♦

Robert N. McCollom, central station supervisor for the Westinghouse Electric Corp. at Detroit, has been given a year's leave of absence to aid in the nation's preparedness program. He will work in the Power Equipment Division of the National Production Authority in Washington, D. C., in charge of the Switchgear Section.

♦

Previously service sales manager, **Donald N. Arndt** has been named assistant general sales manager of the Marvel-Schebler Products division of Borg-Warner Corp.

♦

The appointment of **William F. Arnoldy** as special representative of the Townsend Co., New Brighton, Pa., was announced recently. As a representative in locknut development and application, Mr. Arnoldy brings to the company experience gained in more than ten years with Boots Aircraft Nut Corp. and The Nylok Corp. He will have his headquarters in New Brighton and will direct the sales of the company's line of locknuts.

♦

Arcos Corp., welding electrode manufacturer of Philadelphia, has transferred **J. R. Collins** to its newly opened sales office in Chicago. He has been sales representative in the Philadelphia territory since 1946.

♦

Election of **George W. Marshall Jr.** and **Alvin F. Heinsohn** as vice presidents of Raybestos-Manhattan Inc. was announced recently. Mr. Marshall, who has been sales manager of the company's asbestos products division since 1947, will continue to direct sales activities on asbestos brake linings, clutch facings, asbestos textiles,

Fine machines begin with FINE BEARINGS



Despite the emergency you are probably doing some long-range planning . . . exploring the possibilities of the day when all-out production of civilian goods will again demand emphasis on advanced design.

In exploring the possibilities of your products' future, it will pay you to remember this basic truth: Fine machines begin with fine bearings . . . and "fine bearings" is simply another way of saying Ahlberg Bearings.

For more than four decades design engineers have found that Ahlberg Bearings offer outstanding opportunities for improving design, increasing stamina, reducing maintenance and cutting cost.

Of course, right now, early delivery promises on non-military requirements are next to impossible, but there's never a shortage of sound engineering service at Ahlberg. Please feel free to ask for it at any time. Ahlberg Bearing Company, 3025 W. 47th St., Chicago 32, Illinois.

AHLBERG

BALL BEARINGS

ENGINEERED AND BUILT FOR THE WORLD'S FINEST EQUIPMENT



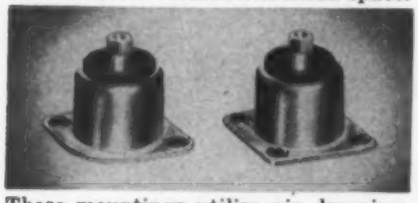
AUTOMOTIVE . . . INDUSTRIAL . . . AIRCRAFT . . . MARINE . . . ARMAMENT

SHOCK and VIBRATION NEWS

BARRYMOUNTS FOR ASSURED CONTROL OF SHOCK AND VIBRATION

SMALL AIR-DAMPED BARRYMOUNTS
for Miniaturized Airborne Equipment

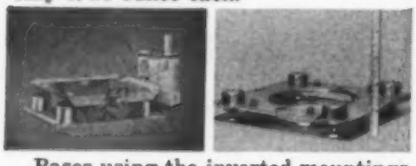
New-series Barrymounts, designed to meet requirements for compact isolators usable with miniaturized equipment, provide effective shock and vibration isolation in small space.



These mountings utilize air damping to minimize shock of aircraft landing and taxiing and to limit excursion so there is no snubber contact, even at resonance.



Upright and inverted types are available for two-hole or four-hole mounting. Unit mountings are one inch in diameter and 1-1/32 inches high under maximum rated load. Load ratings are 0.1 to 3.0 pounds per mount. The mountings weigh only 5/16 ounce each.

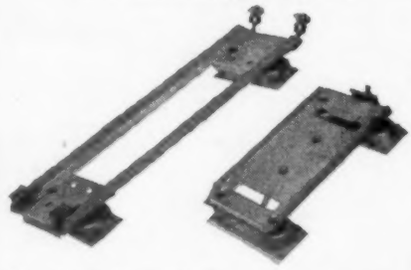


Bases using the inverted mountings raise the mounted equipment only 1/2 inch. Either upright or inverted unit mountings can be furnished on bases that conform to your specifications, load-ratings, and dimensions.

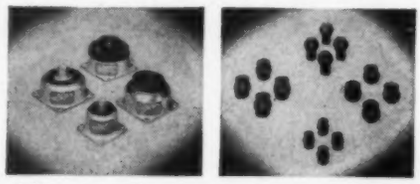
FREE CATALOGS

- 502 — Air-damped Barrymounts for aircraft service; also mounting bases and instrument mountings.
- 509 — ALL-METL Barrymounts and mounting bases for unusual airborne applications.
- 605-606 — Miniaturized air-damped Barrymounts for use with airborne equipment.

STANDARD MOUNTINGS ISOLATE VIBRATION
Available for Aircraft, Marine, Mobile, Instrument, and Industrial uses.

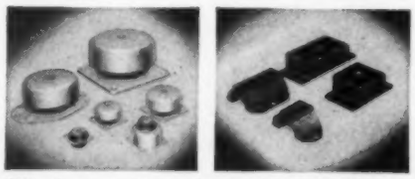


Standard bases built to meet government specifications can be furnished by Barry; special bases can be supplied in sizes and load ratings to fit customers' exact requirements, including miniaturized bases. See catalog 502 and data sheets 605 and 606.



Aircraft vibration isolators designed to meet Army, Navy, and CAA requirements are available in ¼-pound to 45-pound unit ratings; also miniature mounts to 0.1 lb. See catalogs 502 and 509 and bulletins 605-6.

Instrument mountings are furnished for electronic components, tiny, fractional-HP motors, record changers, dictating machines, and other lightweight apparatus. See catalogs 502 and 504.



Shock mountings for mobile, railroad, and shipboard service also give vibration isolation at frequencies above 2000 c.p.m.; useful for general sound isolation. See catalog 504.

Industrial mountings isolate vibration from fans, motor-generator sets, transformers, punch presses, and other heavy industrial equipment. Bulletin 607 tells how to cut maintenance costs with Barrymounts.

THE BARRY CORP.

722 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

New York Rochester Philadelphia Washington Cleveland Dayton Detroit
Chicago Minneapolis St. Louis Seattle Los Angeles Dallas Toronto

mechanical packings and powdered metal friction material. His headquarters are at the company's Manheim, Pa., plant. Mr. Heinsohn will be vice president in charge of the General Asbestos & Rubber division at North Charleston, S. C. He has been general manager of this plant since 1944.

♦

J. C. L. Brown has been appointed sales manager, machinery division of the Gardner Machine Co., Beloit, Wis., manufacturer of disk grinders and abrasives. Formerly, Mr. Brown was associated with the Landis Tool Co. for 21 years.

♦

The De Laval Steam Turbine Co. of Trenton, N. J., has appointed **T. A. Nilsen** as district manager of a new office recently opened in the Esperson Bldg., Houston, Tex. **A. N. Sarich,** for several years southwest technical representative in Oklahoma and Texas, will continue in that capacity with headquarters in the new Houston office.

♦

E. R. Almdale has been appointed manager of the Michigan district for Carboloy Co. Inc., Detroit. Since joining the company in 1940, Mr. Almdale has held various engineering and sales positions.

♦

Ampco Metal Inc., Milwaukee, has announced the appointment of **Louis C. Begg** as district manager of the newly established Buffalo sales division. Mr. Begg was transferred from the company's main office in Milwaukee, where for the past three years he has served as special sales engineer for centrifugal pumps and for all Ampco alloys and products.

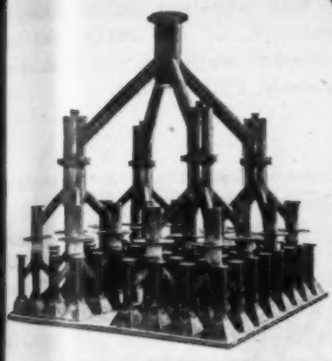
♦

E. E. Hardesty, well known executive in the field of fibrous glass and laminates, has become associated with Narmco Inc. of San Diego and Costa Mesa, Calif., manufacturer of Fiberglas laminates and metal-to-metal adhesives used in aviation and other industries.

♦

General Electric Co. has appointed **Anthony F. Forni** to the position of GE mycalex sales development supervisor for the plastics division of the company's chemical department. Mr. Forni formerly served as a production engineer for both the General Chemical Co. and the Firestone Steel Products Co. General Electric also

Steel-Weld FABRICATION



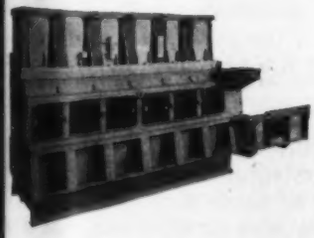
One of Several Parts of a Catalytic Cracking Plant Produced for the Petroleum Industry.



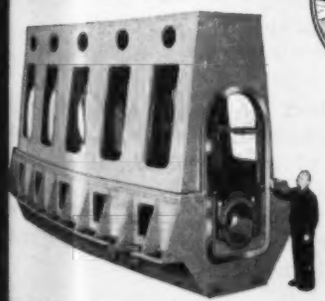
Pressure Vessels for the Chemical and Allied Industries.



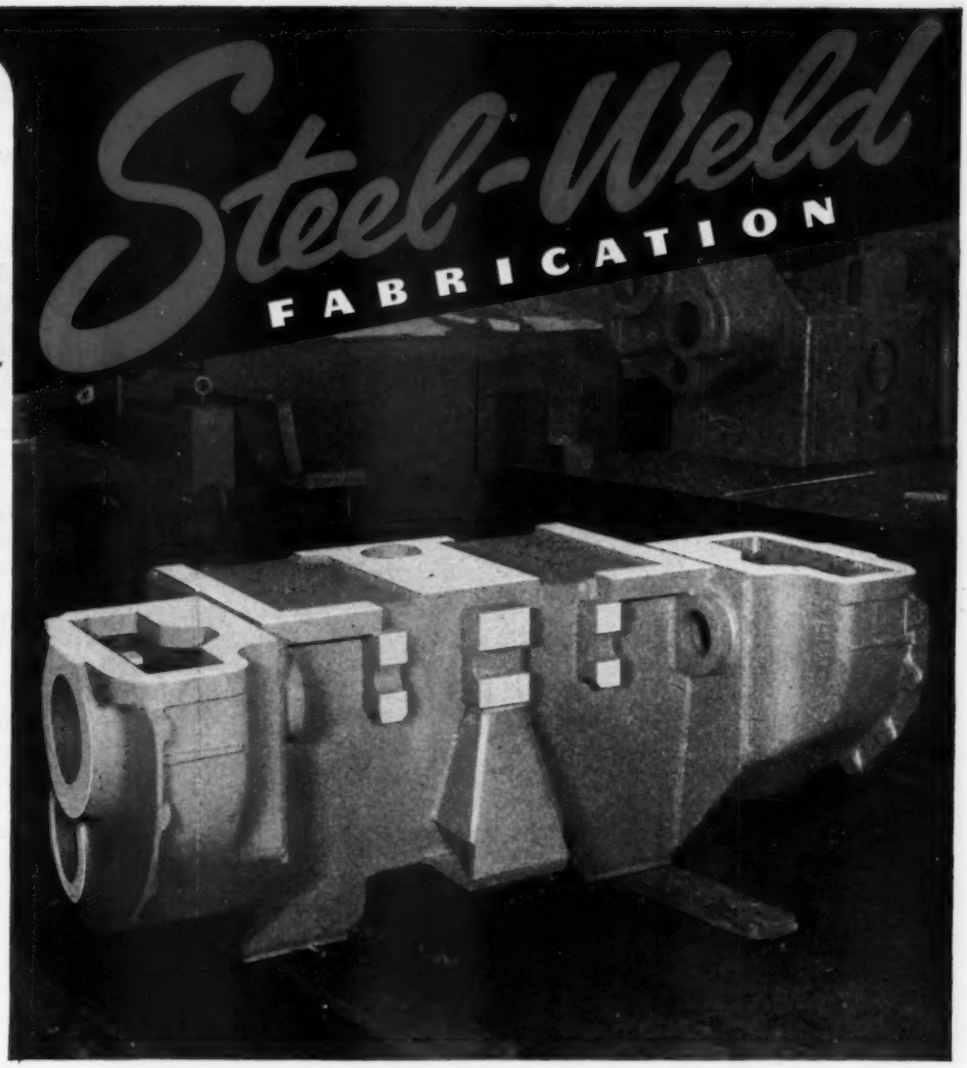
Heavy Press and Machine Frames and Bases for the Machine Tool Industry.



Diesel Engine Crank Cases and Frames for the Marine and Electro-Motive Field.



Crank Cases, Frames, and other Parts for Manufacturers of Marine Steam Engines of Uniflow or Multiple Expansion Type.



Use WELDED STEEL for Greater Strength with Less Weight!



This massive clutch and drive housing for a twenty-one ton tractor is another example in which Steel-Weld Fabrication has been employed to good advantage . . . it is typical of heavy machinery parts and assemblies produced and machined by Mahon for many manufacturers throughout the country. If savings in either time or cost can be effected in your product through Steel-Weld Fabrication of parts, or, if you are cramped for manufacturing space, it will pay you to investigate Mahon facilities. You will find in the Mahon organization an unique source with complete, modern fabricating, machining and handling facilities for any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures you a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

NOW
...a BRASS
TRIPLE-LOK



NOW
TRIPLE-LOK

the "Industry Standard" tube fitting is made in steel, stainless steel, aluminum alloy *and brass.*

MADE BY THE WORLD'S LARGEST MANUFACTURER OF LEAKPROOF TUBE FITTINGS.

- precision-made to be *leakproof* under even the severest operating conditions.
- holds *leakproof* beyond tube bursting pressures.
- 3-piece design – *remains leakproof* after repeated reassembly.
- accomodates full range of standard tube wall thicknesses.
- shape bodies machined from forgings, other parts from bar stock.
- meets ALL industry standards for tube fittings.
- made in wide range of shapes and sizes.

STOCKED BY AUTHORIZED DISTRIBUTORS IN PRINCIPAL CITIES ACROSS THE COUNTRY

THE PARKER APPLIANCE COMPANY
17325 EUCLID AVENUE, CLEVELAND 12, OHIO
5827 W. CENTURY BLVD., LOS ANGELES 43, CAL.

Parker
TUBE FITTINGS
VALVES · O-RINGS

The PARKER Appliance Company
Cleveland 12, Ohio

Please send me my free copy of Tube Fittings Catalog 203.

Name_____

Company_____

Address_____

City_____ State_____

recently named **L. B. Gezon** and **A. Huntsman** to serve as sales manager and assistant sales manager respectively, of the metal-clad and switchboard section of the switchgear divisions at Philadelphia.

♦

Formerly industrial sales manager **A. Charles Amann** has been appointed general sales manager of the Stamford division of the Yale & Town Manufacturing Co. In his new post Mr. Amann will direct all sales of products manufactured at both the Stamford and Salem divisions.

♦

Harold Maron has joined Nielsen Hydraulic Equipment Inc., 298 Lafayette St., New York, N. Y., as sales engineer in charge of the area covering the New England states and part of New York state.

♦

To meet the increased demand created by the defense program, F. J. Stokes Machine Co., Philadelphia, has augmented its regular staff of six expediters with six additional full time men, all of whom were drawn from the sales staff. These men have been taken from their normal selling duties in an effort to maintain delivery dates in spite of longer supplier deliveries.

♦

Frederick F. Sylvester has been appointed to the staff of General Ceramics & Steatite Corp., Keasbey, N. J. He previously served as sales manager of the engineered products division of Air Associates Inc.

♦

A Milwaukee district sales office has been established by Century Electric Co. of St. Louis, with **William Helm** as district sales manager and head of the office. Mr. Helm brings to Milwaukee ten years of sales and application experience gained in the company's Atlanta and St. Louis offices.

♦

Robert G. Leary has been elected vice president and general sales manager of the Rigidized Metals Corp., Buffalo. He was general sales manager for Eastern Stainless Steel Corp., Baltimore, before joining Rigidized Metals in 1950.

♦

Four new appointments have been made by Spring Packing Corp., Chicago. **John B. Welch** has been made assistant vice president; **W. Huntley McPhee**, assistant vice president; and

It's amazing what you can do

in one draw...



MAGNESIUM

Designers and production men, unfamiliar with magnesium, are usually surprised at the drawability of the material. While it isn't quite so easy to draw as pictured above, the practice of hot forming magnesium does permit deformations seldom possible in any other metal.

Generally speaking, magnesium alloys can be hot drawn in one operation to a depth equal to 80% reduction in blank size. This often eliminates the need for multiple stage dies, speeds up the operation, and reduces processing costs even though preheating of the sheet and dies is required. Since hot forming is used, spring-back problems are greatly reduced.

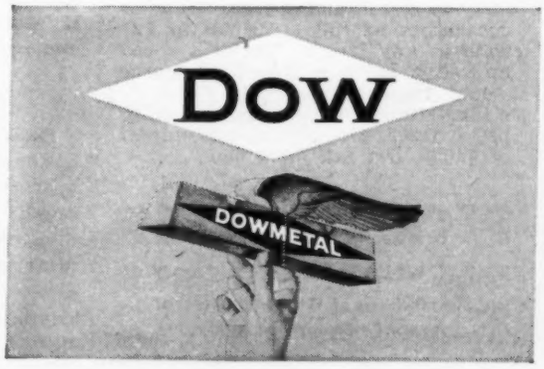
Almost any press found in the ordinary press shop can be used to draw magnesium, although hydraulic presses are preferred when the draw is severe and controlled speeds are required. Dies are similar to those used on other metals.

For additional information on drawing or forming magnesium, call your nearest Dow sales office or write direct.

Magnesium Division, Dept. MG-131

THE DOW CHEMICAL COMPANY
MIDLAND MICHIGAN

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit
Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada



Fast, Efficient, Low-Cost

WHITEPRINTERS

for Plant, Lab, Office



SPEE-DEE

Saves up to 80% of Commercial Blue Print Costs!

● Quickly make accurate black-on-white or blue-on-white prints up to 24" x 36" from translucent originals, at less than 2c per sq. ft. Just plug into 115 volt a.c. line. Makes photocopies too. Uses diazo (moist or ammonia dry) process. $155.81 includes initial supply of paper and developing powder. Printer only, $149.81. Shipping weight, 85 lbs. Smaller models from $55.12. *Order the Spee-Dee on 10-days free trial or write for full facts.*



MODEL "D" VERSA-LINER

Volume Production—Prints when Needed

● Economically prints and develops black line and colored line whiteprints. Uses dry ammonia-fume diazo method. Plugs into standard 115 V 60 cycle a.c. line, using 19 amps. Easy to install and operate. Handles cut sheets or roll stock up to 42" wide in any length. Variable speed up to 5 ft. per min. New light source —low replacement cost. Easy to clean. Minimum maintenance. Complete, $1295. Moist diazo-type model at $1095. *Get full facts now.*

PECK & HARVEY

5747 N. WESTERN AVE., CHICAGO 45

Manufacturers of Whiteprint, Blueprint and Photocopy Equipment

Carl A. Schroeder and **Lee C. Van Hooser**, regional managers in New York and Los Angeles, respectively. The main activities of these men will be directed toward the distribution and handling of the company's line of Chrome Lock impregnated felt gasketing tapes.

♦

A sales engineer in the factory office of Esterline-Angus Co. Inc. for several years, **Robert F. Lamb** has been appointed sales and service engineer for Esterline-Angus recording instruments and their associated products in western New York.

♦

James S. Anderson, assistant general sales manager of the Babcock & Wilcox Tube Co., Beaver Falls, Pa., has assumed the duties of chief of the newly created Tubing Section of the Iron & Steel Division of the Industries Operations Bureau of the National Production Authority. He came to Babcock & Wilcox in 1941 and since 1948 has been assistant general sales manager.

♦

Kennametal Inc., Latrobe, Pa., has appointed **Gordon Kimball** as application engineer in the company's district office at 1537 Main St., Springfield, Mass., and **F. O. Hill** as application engineer at the Cleveland district office, 2443 Prospect Ave.

♦

F. R. Dickerson has been appointed to the position of general manager of the pump division of the Geo. D. Roper Corp., Rockford, Ill. Mr. Dickerson joined the company in 1936 as a sales engineer and in 1948 was made sales manager, the position he held until his new appointment.

♦

Promotion of two executives at the National Malleable and Steel Castings Co. Indianapolis plant was announced recently. **Mark M. Miller** was appointed sales manager, and **John H. Murphy** was made assistant sales manager.

♦

Karl W. Osterstrom, a specialist in the design and development of air-operated hydraulic pumps, has been appointed manager of the new pump division recently opened by the Binks Manufacturing Co. of Chicago. Mr. Osterstrom will be in charge of sales, engineering and development for the new division.

BOSTON Gear STOCKS ARE Here at factory prices

Save time and money—assure yourself of uniform quality and parts interchangeability by standardizing on Boston Gear quality products—stocked at these Authorized Boston Gear Distributors—one near you!

AKRON, OHIO
Bearing Distributors, Inc.
280 E. Exchange St.
ALBANY, NEW YORK
Sager-Spuck Sup. Co.
364-366 Broadway
ALLENTOWN, PENNSYLVANIA
Wm. H. Taylor & Co., Inc.
250-256 Hamilton St.
ATLANTA, GEORGIA
J. M. Tull Metal & Sup. Co.
285 Marietta St.
BALTIMORE, MARYLAND
Carey Mchy. & Sup. Co.
3501 Brehm's Lane
BIRMINGHAM, ALABAMA
Owen-Richards Co., Inc.
1009 2nd Ave. N.
BOSTON, MASSACHUSETTS
Chandler & Farquhar, Inc.
900 Commonwealth Ave.
BRIDGEPORT, CONNECTICUT
Hawley Hardware Co.
1120 Main St.
BROOKLYN, NEW YORK
H. L. Dickie
314-36th St.
BUFFALO, NEW YORK
Root, Neal & Co.
44 Peabody St.
CHARLOTTE, NORTH CAROLINA
Matthews-Morse Sales Co.
301 East 7th St.
CHATTANOOGA, TENNESSEE
Volunteer Bearing & Transmission Co., Inc.
3000 South Broad St.
CHICAGO, ILLINOIS
Boston Gear Works
955 W. Washington Blvd.
Chgo. Pulley & Shafting Co.
23 N. Desplaines St.
Samuel Harris & Co.
114-116 N. Clinton St.
Power Trans. Equip. Co.
1245 W. Fulton St.
CINCINNATI, OHIO
Queen City Sup. Co.
Pearl & Elm Sts.
CLEVELAND, OHIO
Bearing Distributors, Inc.
2618 Carnegie Ave.
Boston Gear Works
211 St. Clair Ave., N. W.
Mau-Sherwood Sup. Co.
800 Lime Road
COLUMBUS, OHIO
Ohio Trans. Co.
466 Parsons Ave.
DALLAS, TEXAS
Geo. J. Fix Co.
2413-15 Commerce St.
DAYTON, OHIO
Klinger-Dills
1041 So. Patterson Blvd.
DENVER, COLORADO
Western Belting & Packing Co.
1720-28 Wazee St.
DES MOINES, IOWA
Standard Bearings Co.
1014 Grand Ave.
DETROIT, MICHIGAN
Chas. A. Strelinger Co.
149-165 E. Larned St.
GRAND RAPIDS, MICHIGAN
Mackay Industrial Sales Co.
704 Jefferson, S. E.
GREENSBORO, NORTH CAROLINA
Trans. Supplies, Inc.
403 Walker Ave.
HAMILTON, ONTARIO
Renold-Coventry, Ltd.
443 King St. E.
HARTFORD, CONNECTICUT
Sillitor-Holden, Inc.
433 New Park Ave.
HOUSTON, TEXAS
Geo. J. Fix Co.
2702 Polk Ave.
INDIANAPOLIS, INDIANA
Vonnegut Hardware Co.
402 W. Maryland St.
JACKSONVILLE, FLORIDA
S. B. Hubbard Co.
32 W. Bay St.
KANSAS CITY, MISSOURI
Elfreldt Mchy. & Sup. Co.
1219 McGee St.
KNOXVILLE, TENNESSEE
Hoyt N. Payne Co.
410 E. Depot Ave.
LANCASTER, PENNSYLVANIA
Herr & Co., Inc.
Prince & Chestnut Sts.
LONDON, ONTARIO
Renold-Coventry, Ltd.
1024 Oxford St., East
LONG ISLAND CITY, NEW YORK
L. C. Bigelow & Co., Inc.
11-06 Jackson Ave.
LOS ANGELES, CALIFORNIA
Andrews Hardware & Metal Co.
334 S. Main St.
Garrett Supply Co.
3844 S. Santa Fe Ave.
LOUISVILLE, KENTUCKY
Industrial Equip. Co.
1377 South 7th St.
MEMPHIS, TENNESSEE
Lewis Sup. Co.
Main at Butler Sts.
MIAMI, FLORIDA
Gendas Corp.
2140-50 N. Miami Ave.
MILWAUKEE, WISCONSIN
Western Iron Stores Co.
319-331 East Chybourn St.
Wisconsin Bearing Co.
915-917 N. Market St.
MINNEAPOLIS, MINNESOTA
R. C. Duncan Co., 1300 4th St. S.
Industrial Supply Co.
1100-08 3rd Ave. S.
MONTREAL, QUEBEC
Renold-Coventry, Ltd.
1006 Mountain St.
NEWARK, NEW JERSEY
Squier, Schilling & Stiff
419 Plane St.
NEW ORLEANS, LOUISIANA
McLellan A-C Sup. Co.
2375 Tchoupitoulas St.
NEW YORK, NEW YORK
L. C. Bigelow & Co., Inc.
250 W. 54th St.
Boston Gear Works, 480 Canal St.
Frank Tracy, Inc., 202 Centre St.
OAKLAND, CALIFORNIA
C. W. Marwedel
11th & Alice Sts.
PHILADELPHIA, PENNSYLVANIA
Boston Gear Works
Broad St. Car. of Lycoming & 16th St.
Lindsay, Oberholtzer & Co.
4432 Ridge Ave.
Meredick & Company
42 N. Sixth St.
PITTSBURGH, PENNSYLVANIA
Somers, Fitler & Todd Co.
313-327 Water Street
PORTLAND, OREGON
Woodbury & Co.
133 S. W. 2nd Ave.
PROVIDENCE, RHODE ISLAND
Machine Parts Corp.
271 Washington St.
QUEBEC, QUEBEC
Renold-Coventry, Ltd.
5 Bourlamaque Ave.
QUINCY, MASSACHUSETTS
Boston Gear Works
14 Hayward St.
RICHMOND, VIRGINIA
Industrial Sup. Co.
15th & Franklin Sts.
ROCHESTER, NEW YORK
John M. Forster Co.
110 Mill St.
ST. LOUIS, MISSOURI
Calcara-Wright Mchy. & Sup. Co.
1223-1229 N. Broadway
SAN FRANCISCO, CALIFORNIA
Boston Gear Works
123 10th St.
C. W. Marwedel
1235 Mission St.
SEATTLE, WASHINGTON
Cragin & Co.
932 First Ave. S.
SPRINGFIELD, MASSACHUSETTS
Boston Gear Works
19 Worthington St.
SYRACUSE, NEW YORK
Syracuse Sup. Co.
314 W. Fayette St.
TAMPA, FLORIDA
Southern Pump & Sup., Inc.
902 Twiggs St.
TOLEDO, OHIO
Ohio Belting & Trans. Co.
406 Orange St.
TORONTO, ONTARIO
Renold-Coventry, Ltd.
50 Edward St.
TRENTON, NEW JERSEY
Wiley-Hughes Sup. Co.
801 New York Ave.
VANCOUVER, B. C.
Renold-Coventry, Ltd.
1066 Seymour St.
WATERBURY, CONNECTICUT
White Supply Co.
297 Thomaston Ave.
WILKES-BARRE, PENNSYLVANIA
Holmes Metallic Co.
519-521 S. Main St.
WINSTON-SALEM, NORTH CAROLINA
Koster Machinery Co.
300 E. 3rd St.
WORCESTER, MASSACHUSETTS
W. M. Steele Co.
171 Fremont St.

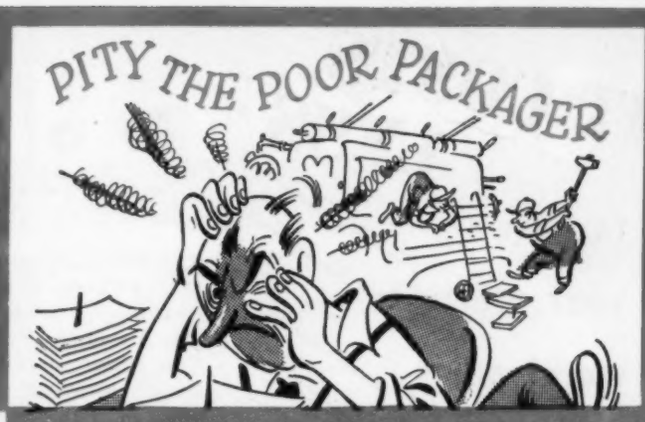
BOSTON Gear STOCKS ARE Near



TEN "BARGAIN PRICE" GEARS SAVED HIM $10.50 — AND COST HIM $96.00

It was a printing press drive. The five pairs of gears soon wore out and were replaced by BOSTON Spur Gears cut 20° Pressure Angle*

Cost of pulling down press and replacing gears (two men, 4 hrs. @ $2.00 per hr.)	$16.00
Down Time loss (profit and overhead) 10 reams per hr. @ $2.00 per ream	$80.00
TOTAL	$96.00



FOUR "BARGAIN PRICE" GEARS SAVED HIM $2.40 — AND COST HIM $178.00

Four inferior gears driving a packaging machine had to be replaced by BOSTON Gears.

Cost of repairing machine (one man, 8 hrs. @ $2.25 per hr.)	$18.00
Down Time loss (profit and overhead) — 8 hours production, 2000 units per hr. @ $0.01 apiece	$160.00
TOTAL	$178.00

DON'T LET *Yourself* IN FOR LOSSES LIKE THESE

*LOOK WHAT BOSTON 20° PRESSURE ANGLE GEARS SAVE YOU!



Specify Boston 20° Pressure Angle Gears instead of the ordinary 14½° P.A. gears of identical horsepower rating and save:

21.2% in COST
23.4% in WEIGHT
16.9% in SPACE

Ask your nearby Boston Gear Distributor for Boston 20° Pressure Angle Gears.

STANDARDIZE ON STOCK BOSTON GEARS
DESIGN THEM INTO YOUR EQUIPMENT
ALWAYS SPECIFY THEM FOR REPLACEMENTS



Write for free copy of Boston Gear Catalog No. 55.

BOSTON *Gear* stocks are *Near*

(see adjacent list of Authorized Boston Gear Distributors)

BOSTON GEAR WORKS

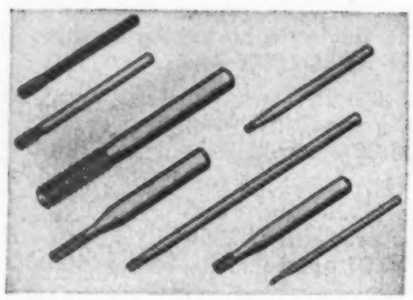
64 HAYWARD ST., QUINCY 71, MASS.



IT COSTS LESS

to have your precision metal parts made by

TORRINGTON



Special equipment and volume production enable us to save for you on a wide variety of precision parts made to order.

Typical are mandrels or spindles for mounted grinding wheels, abrasive points, felt wheels. Shank diameters to .500", close tolerances, centerless ground if desired. Chuck ends rounded, no burrs. Sharp, clear uniform knurls. Concentric tapers. Mandrels accurately hand-straightened.

We are also set up to make for you such parts as special rollers, studs, dowel pins, screw driver and ice pick blades, surgical and dental instruments, pen and pencil barrels, instrument shafts and pivots, special needles, etc.

Send your prints and specifications today for a prompt quotation.

THE TORRINGTON COMPANY
Specialty Department
553 Field Street • Torrington, Conn.

Makers of
TORRINGTON NEEDLE BEARINGS

SALES Notes

SALES of all products of **The Polymer Corp.**, Reading, Pa., have been turned over to a separate company, **The Polymer Corp. of Pennsylvania.** This change was made necessary because of confusion with a Canadian concern of the same name. The Polymer Corp. will now restrict its activities to production, research and development. The Polymer Corp. of Pennsylvania will sell the manufacturing company's Nylon, Teflon and Kel-F rod, strip and tubing, as well as all fabricated products, under the brand name of Polypenco.

♦

The **Aro Equipment Corp.**, Bryan, O., has announced the appointment of **Bruns & Collins Inc.**, Chicago, as direct factory distributor covering lubrication equipment in the northern Illinois territory.

♦

Producer of high alloy static and centrifugal castings, the **Duraloy Co.**, Scottsdale, Pa., has announced the opening of a Detroit sales office which will function as a direct sales branch. It is under the management of W. D. Hazelton and is located at 805 New Center Bldg.

♦

To assist industry in meeting rigid metal finish specifications economically, the Industrial Products Division of the **Elgin National Watch Co.**, Elgin, Ill., has announced the availability of field trained representatives for detailed study of specific fine finishing problems. Backed by the research and findings of the Elgin Laboratories, they will assist without obligation in the development of methods and techniques for maximum finishing efficiency.

♦

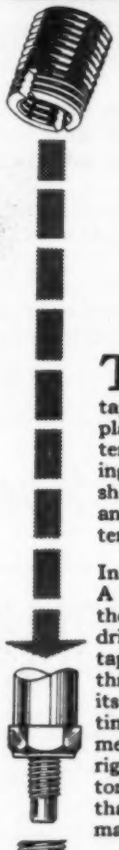
Glass Fibers Inc. has moved to a new location at 1810 Madison Ave., Toledo 2, O.

♦

Merger of two wholly owned Cummins sales and service organizations with Cummins Diesel Sales Corp. and the appointment of a general manager has been announced by **Cummins Engine Co. Inc.**, Columbus, Ind. William B. Lawrence, formerly Cummins Engine Co. regional manager for the Rocky Mountain region with

IS THREAD STRIPPING YOUR PROBLEM?

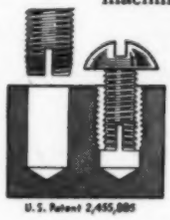
Use TAP-LOK INSERTS



for stronger-- durable threads

The Tap-Lok Insert greatly increases the strength of tapped threads in aluminum, plastics, wood and other materials of relatively low shearing strength. By enlarging the shear area it provides a firm anchorage for threaded fastenings of various types.

Installation is easy and rapid. A simple driving tool turns the insert into a cored or drilled hole equal in size to a tap drill hole for the external thread of the insert. It taps its own thread with the cutting edges of its slotted segments. The insert remains rigidly in place because the torque to dislodge it is greater than the torque a standard machine screw can withstand.



U.S. Patent 2,455,085

The Tap-Lok Insert eliminates the uncertainties, losses and weaknesses of molded-in and cast-in inserts — improves the product at lower costs.

Send for samples and descriptive folder.

Also manufacturers of Groov-Pins—for positive locking press fit.



GROOV-PIN CORPORATION
2013 Kerrigan Avenue
Union City, N. J.

headquarters in Denver, Colo., has been named general manager of the sales corporation, which has headquarters at Columbus. Subsidiaries affected by the merger are Cummins Diesel Sales Corp. of Illinois at Chicago and Cummins Diesel Sales and Service of New York Inc., at New York City. These two organizations are now identified with Cummins Diesel Sales Corp., which also includes Cummins dealerships with operating headquarters at St. Paul, Omaha, Neb., Indianapolis, and Memphis, Tenn.

♦

Ehret and Kinsey, Chicago sales representative of the **Cleveland Worm and Gear Co.** and **The Farval Corp.,** has moved to new and larger quarters in the Board of Trade Bldg., 141 West Jackson Blvd.

♦

The appointment of the **J. M. Grimstad Co.** as sales and service representative for the Minnesota and northwestern Wisconsin area was announced recently by **Greer Hydraulics Inc.** Robert Hazelrigg, with headquarters at the Minneapolis office, 2509 30th Ave. South, will be in charge of sales and service of Greer hydraulic accumulators, filters, valves and other hydraulic system components for industrial application.

♦

Frank Tracy Inc., 202 Centre St., New York, N. Y., has been named a dealer for **Allis-Chalmers** motors in Westchester, New York, Kings, Queens, Nassau, Suffolk and Richmond counties in New York State.

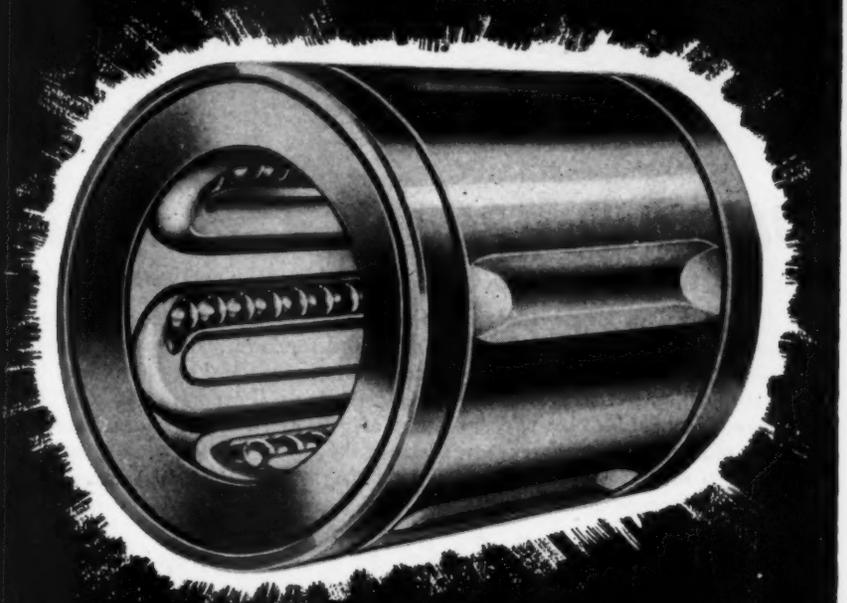
♦

Raytheon Manufacturing Co. of Waltham, Mass., has announced the transfer of its New York and international sales offices to 19 Rector St., New York 6, N. Y. This new location offers advantages contributing to the maintenance of prompt and efficient service to dealers and customers both abroad and in the New York sales district, which covers New York, lower Connecticut, New Jersey, Delaware, Pensylvania, Virginia, District of Columbia and North Carolina.

♦

The **Gisholt Machine Co.** has announced the establishment of a new balancing school. This school is being conducted at the factory in Madison, Wis. Instruction is in the form of classroom lectures, discussion periods, and practical applications of balancing. The course of study covers basic fundamentals of balancing at both shop and engineering levels.

BALL BUSHING



The BALL BEARING for your

LINEAR MOTIONS

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision *Series A* BALL BUSHINGS.

And now hundreds of original equipment manufacturers use the low cost Commercial *Series B* BALL BUSHINGS which were developed for support of linear motions in competitively priced, volume manufactured products where super precision is not essential.

Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product. Up-date your design and engineering with BALL BUSHINGS!

LOW FRICTION • LONG LIFE
ELIMINATES BINDING AND CHATTER
SOLVES SLIDING LUBRICATION PROBLEMS
LASTING ALIGNMENT • LOW MAINTENANCE

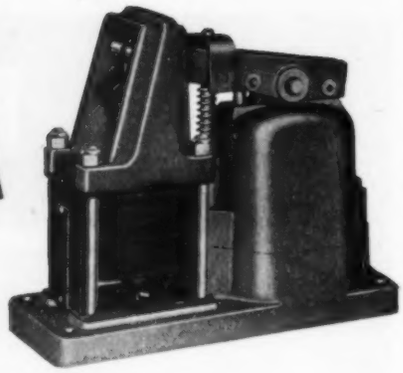
Now manufactured for 1/4", 1/2", 3/4", 1" and 1 1/2" shaft diameters.

Write for descriptive literature and the name of our representative in your city

THOMSON INDUSTRIES, INC., Dept. E
MANHASSET, NEW YORK

PROGRESSIVE MANUFACTURERS USE BALL BUSHINGS – A MAJOR IMPROVEMENT AT A MINOR COST

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves



No. 1491-CS-3
½" 3-Way Solenoid
Operated Air Valve

SOLENOID OPERATED Air Valves

fast, positive, dependable operation

● These valves are widely used for controlling single action air cylinders, clutches, etc. Can be operated with a variety of power switches, mercoid switches or automatic contact switches activated by moving objects. Stainless steel push-pull rods, brass sleeves and U-packings expanded by pressure and all enclosed against dirt, assure long, efficient, trouble-free operation. No metal to metal seating. Precision made. Individually tested. Spring or double solenoid return. ⅜" to 1½" sizes: 2-way, 3-way and 4-way actions. *Write for full details.*

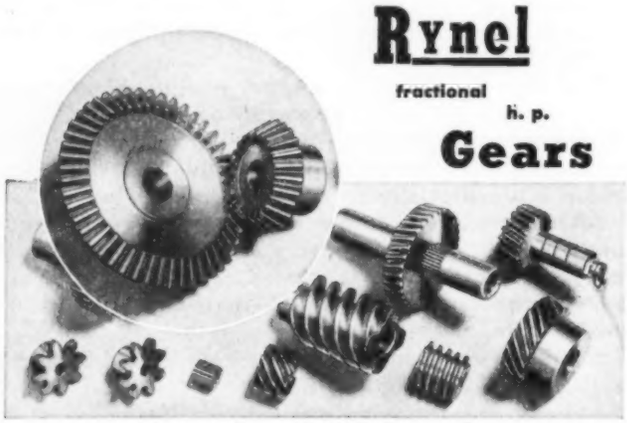
THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1949 East Pershing St., Salem, Ohio

Rynel
fractional h. p.
Gears



Certified—**BLANK TO FINISHED GEAR**

Rynel Certified Gears are made exactly to your specifications. Accuracy, tooth form and finish are controlled from the start, using accurately formed blanks from our own blanking department. Experienced gear men cut them on the latest precision equipment. Finished quality is checked by skilled gear inspectors. ● That's why designers, engineers and product development men recognize Rynel Certified Gears for quality and dependability.

SPUR ● HELICAL ● WORM ● WORM GEAR ● INTERNAL ● SEGMENT SPROCKET ● RATCHET ● STRAIGHT-TOOTH BEVEL GEARS

Send For Our Latest Bulletin

Rynel Corporation
301 MILLER ST., STERLING, ILLINOIS

Meetings

AND EXPOSITIONS

June 15-30—

Seattle International Japanese Trade Fair to be held in the Edmundson Pavilion, Seattle, Wash. Additional information may be obtained from John M. Haydon, Promotion Committee, c/o Port of Seattle, P. O. Box 1878, Seattle 11, Wash.

June 18-20—

American Society of Agricultural Engineers. Annual meeting to be held at the Rice Hotel, Houston, Texas. Raymond Olney, P.O. Box 229, St. Joseph, Mich., is secretary.

June 18-22—

American Society for Testing Materials. Annual meeting to be held at the Chalfonte-Haddon Hall, Atlantic City, N. J. Additional information may be obtained from society headquarters, 1916 Race St., Philadelphia 3, Pa.

June 22-23—

American Society of Mechanical Engineers. Applied Mechanics West Coast National Conference to be held at Stanford University, Stanford, Calif. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

June 25-29—

American Society for Engineering Education. Annual meeting to be held at Michigan State College, East Lansing, Mich. Arthur B. Bronwell, Northwestern University, Evanston, Ill. is secretary.

June 25-29—

American Institute of Electrical Engineers. Summer general meeting to be held at the Royal York Hotel, Toronto, Ontario, Canada. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

June 25-29—

American Society of Mechanical Engineers. Oil and Gas Power Division Conference to be held at the Baker Hotel, Dallas, Texas. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

June 27-28—

Institute of the Aeronautical Sciences. Annual Spring meeting to be held at the Western Headquarters Bldg., 7660 Beverly Blvd., Los Ange-

les, Calif. Additional information may be obtained from Robert R. Dexter, secretary, 2 East 64th St., New York 21, N. Y.

July 30-Aug. 2—

American Electroplaters' Society. 38th annual meeting to be held at the Statler Hotel, Buffalo, N. Y. Additional information is obtainable from American Electroplaters' Society, 473 York Rd., Jenkintown, Pa.

Aug. 13-15—

Society of Automotive Engineers. West Coast meeting to be held at the Olympic Hotel, Seattle, Wash. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Aug. 30-Sept. 13—

The British Engineers Association. Engineering, Marine and Welding Exhibition to be held in Olympia, London, England. Additional information may be obtained from J. V. Topham, secretary, 32 Victoria St., London, S. W. 1., England.

Sept. 3-7—

Institute of the Aeronautical Sciences — Royal Aeronautical Society. Third International Aeronautical Conference to be held at Brighton, Sussex, England. Additional information may be obtained from Robert R. Dexter, secretary, 2 East 64th St., New York 21, N. Y.

Sept. 10-13—

Society of Automotive Engineers. Tractor and production forum to be held at the Biltmore Hotel, Los Angeles, Calif. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Sept. 10-14—

Instrument Society of America. Sixth National Instrument Conference and Exhibit to be held in the Sam Houston Coliseum, Houston, Texas. Additional information may be obtained from society headquarters, 921 Ridge Ave., Pittsburgh 12, Pa.

Sept. 24-26—

American Society of Mechanical Enginners. Petroleum mechanical engineering conference to be held at Hotel Mayo, Tulsa, Okla. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

Sept. 25-28—

American Society of Mechanical Engineers. Fall meeting to be held at Hotel Radisson, Minneapolis, Minn. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

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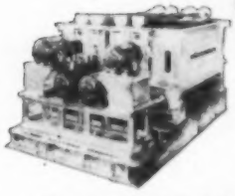
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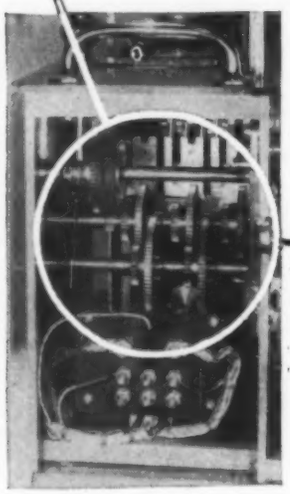
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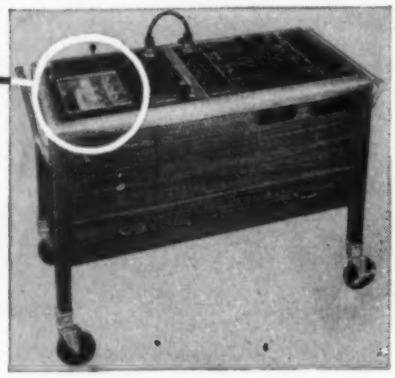
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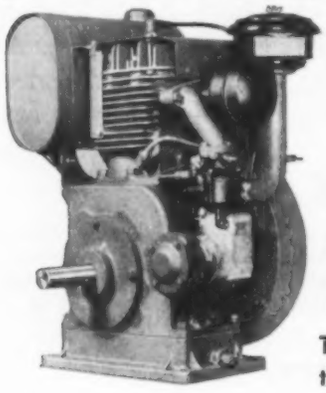


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MODELS	AEH	AFH	AGH	AHH
Bore - - - - - - - - - inches	3	3¼	3½	3⅜
Stroke - - - - - - - - - inches	3¼	4	4	4
Disp. cubic inches - - - - - - - -	23	33.2	38.5	41.3
H. P. and R.P.M. range - - - - - - -	3.9 at	6.0 at	7.2 at	7.7 at
	1600	1600	1600	1600
	6.1 at	7.2 at	8.4 at	9.2 at
	3200	2200	2200	2200
Net weight in lbs., Standard Engine - - -	130	180	180	180

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ing winter. Will maintain 80 to 85 F when outside ambient temperature is 175 F; maintains 68 to 75 F temperature when ambient is zero. Requires no duct work; cooling section installed in cab, condenser section placed outside cab on crane. *Dravo Corp., Pittsburgh, Pa.*

DUST COLLECTOR: For use where remote dust sources have toxic fumes, vapors or obnoxious odors. Requires only 12 by 23-in. floor space; develops rated 437 cfm at 5000 fpm velocity at inlet. Suction adequate to handle buffing, polishing or grinding wheel up to 10-in. diameter, or two smaller wheels from 3 to 7-in. diameter. Powered by ⅓-hp, 3600-rpm motor driving self-clearing paddle-wheel type fan. Solids removed in cyclone separator. *Aget-Detroit Co., Ann Arbor, Mich.*

CEILING VENTILATOR: For kitchens and other small rooms up to 1000 cu ft. Features interchangeable horizontal and vertical discharge. Develops 300 cfm using 1/30-hp motor turning twin 6-in. squirrel-cage blower wheels at 1450 rpm. Slow speed gives quiet operation; motor isolated from air stream. Discharge takes standard 3½ by 10-in. furnace duct. Dimensions, 7¼ by 8⅞ by 14 in. *Trade-Wind Motorfans Inc., Los Angeles, Calif.*

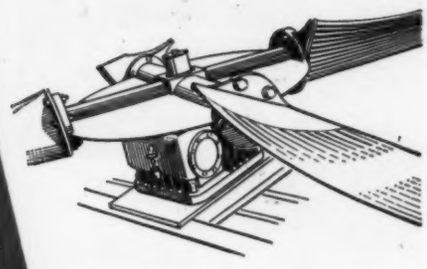
AIR CONDITIONER: Eight-ton model SU-81 designed for homes, factories, offices, etc. All-year-round air conditioning provided by addition of steam or hot water coils and outside air duct for ventilation supply. Packaged units include Freon-12 compressor, condenser, direct-expansion coil, and centrifugal fan. Requires only water, drain and electrical connections. *Westinghouse Electric Corp., Pittsburgh, Pa.*

BLOWER-COOLER: Capacity, 3500 cfm. For cooling offices, homes or commercial buildings. Moving parts all insulated by rubber mounts. Patented water regulator assures equal delivery of water to each pad area, regardless of position of cooler. Powered by ⅓-hp, heavy-duty motor. Unit can be installed in windows or attached to ducts; 4-way directional grille available. *Palmer Manufacturing Corp., Phoenix, Ariz.*

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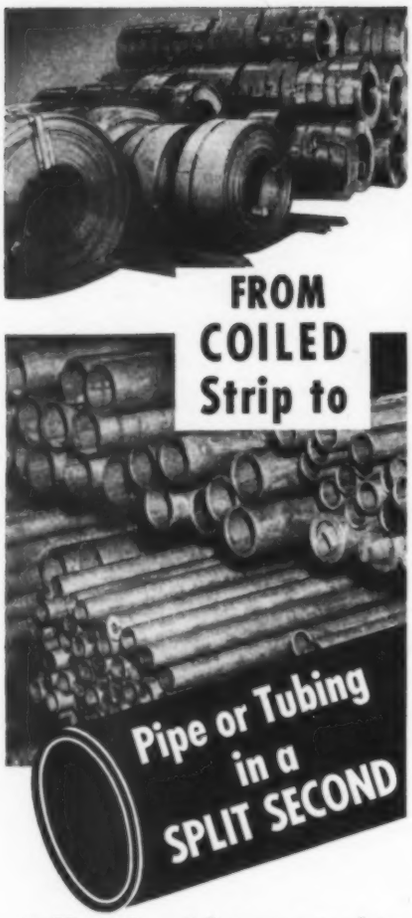
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quench tank. Work automatically loaded, transferred and quenched. Furnace is gas or electric; cooling chamber is water-jacketed, with automatic temperature control. *Ipsen Industries Inc., Rockford, Ill.*

INDUCTION FORGE HEATER: For automatically heating range of billet sizes and shapes to preselected hardness patterns. Machines have hardness range of 50 to 1500 kw. Billet sizes handled, 1 to 4 in. round or square, heated to 2250 F at max rate of 7500 to 8500 lb per hr. Machines have space for 8 heating stations with 30 interchangeable heating units for various size bars. Each station has complete heating equipment and controls. *Ajax Electrothermic Corp., Trenton, N. J.*

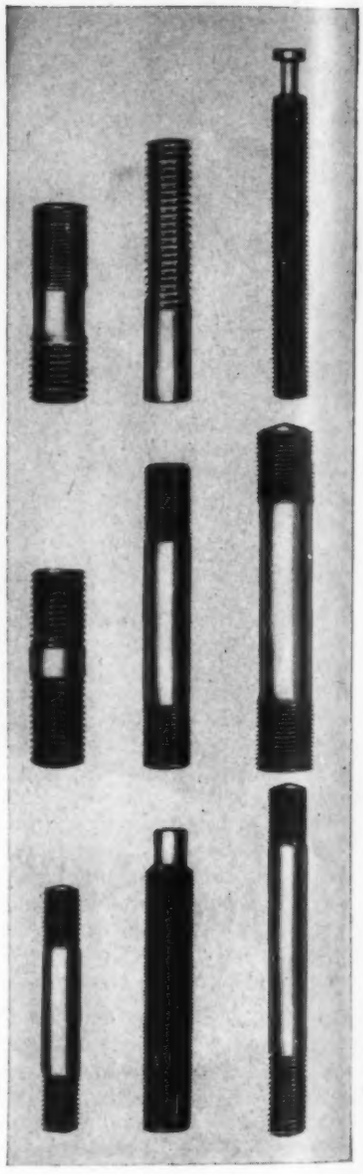
RADIO-FREQUENCY GENERATOR: For dielectric heating of nonmetallic materials such as textiles, rubber, wood, food, etc. Adaptable to batch or continuous production methods delivering rated 20 kw at 100 per cent duty cycle. Built-in load coupling and tuning elements permit max transfer of power into wide range of loads by front panel control. *Westinghouse Electric Corp., Pittsburgh, Pa.*

INDUCTION HEATER: Electronic type 20-kw model with nonventilated, dustproof, NEMA Type 12 enclosure. For high-speed annealing, brazing, hardening and soldering. Designed so that only control and accessories required for particular heating application need be purchased to change to different setup. Available in two models, with and without variable power adjustment. Operate on 230, 460 or 550-v, 3-phase, 60-cycle power supply. *General Electric Co., Schenectady, N. Y.*

Manufacturing

MILLING MACHINE: Production machine designed to use motors up to 2 hp. Spindle accommodates No. 40 American Standard arbors. Hand feed lever standard, screw feed and automatic feeds available. Specifications: table size, 6 by 20 in.; working surface, 4 by 16 in.; longitudinal feed with hand lever or screw, 12 in., with automatic feed, 8 in.; vertical range of head, 5 in.; max cutter diam, 7 in. *Nolan Machinery Co., Rome, N. Y.*

CENTERLESS GRINDER: Max capacity, 1¼-in. stock diameter. Regulating wheel has infinitely variable speed from 35 to 350 rpm; micrometer dial for setting regulating wheel graduated in 0.0001-in. Both wheels contour dressed from single template. Specifications: grinding wheel, 14-in. diam by 7-in. face; regulating wheel, 7-in. diam by 4-



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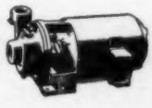
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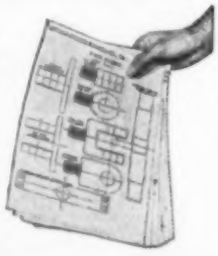
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in. face; main spindle speed, 1600 rpm; grinding wheel motor, 2-hp, 1800-rpm, 220/440-v; regulating wheel motor, ¼-hp. *Diversified Metal Products Co., Los Angeles, Calif.*

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JIG BORERS: Oerlikon production jig borers for precision work. Double-column machines locate holes to 0.0004-in. tolerance between centers, drill holes as small as 0.040-in. diameter. Two models have 18 spindle speeds, 12 feeds. Model R-2 has 38 to 1900-rpm speeds, 0.0012 to 0.031-in. per revolution feeds, 58 5/8-in. clearance between columns, and 25 13/32-in. travel of boring head on crossrail. Model R-3 has 30 to 1500-rpm speeds, 0.0012 to 0.0472-in. per revolution feeds, 65 ¾-in. clearance between columns, 28 ⅜-in. head travel. *The Cosa Corp., New York, N. Y.*

POWER HACK SAW: Heavy-duty model handles 6¾ in. square materials. Has 6-in. stroke, built-in coolant tank, ½-hp single or three-phase motor, swivel vise, automatic feed system, and automatic stop. Takes 12 or 14-in. blades, operates at 70 or 125 strokes per minute. *Sales Service Machine Tool Co., St. Paul, Minn.*

HYDRAULIC PRESSES: Capacities, 5 and 8 tons. Units are complete with built-in reservoir, with motor and pump mounted inside frame. Return ram stroke can be shortened to save time. Force exerted adjustable between 10 and 100 per cent of max capacity. Models F-50A and F-80 have 10-in. max stroke, 16-in. gap, 7½-in. reach, are powered by 2 and 3-hp motors respectively. *Hannifin Corp., Chicago, Ill.*

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spindle driven by 10-hp 1200-rpm motor. Three 1½-hp motors drive table, cross slide and vertical slide at infinitely variable rates between ½ and 25 in. per minute. *Reed-Prentice Corp., Worcester, Mass.*

PORTABLE HAND DRILLS: Model 430 standard-duty electric drill has ⅜-in. capacity in steels, ¾-in. in hard wood. No-load speed, 1000 rpm; length overall, 12¾ in.; weight, 6½ lb. Model 435 has ⅜-in. capacity in metals, ¾-in. in hard wood. No-load speed, 750 rpm; length overall, 13¼ in.; weight, 6½ lb. Both models equipped with Jacobs geared chucks. *Cummins Portable Tools, division of Cummins-Chicago Corp., Chicago, Ill.*

MOLDING MACHINE: For high-speed molding of all thermoplastics. Capacity, 8 oz; locking pressure, 350 tons; die plates, 22⅛ by 28 in. Uses high-speed double-toggle linkage. Machine combines high production rate of small machine with rigid locking of large machine. *Lester-Phoenix Inc., Cleveland, O.*

DROP HAMMER: Model C Ceco-Drop piston-lift, gravity drop hammer designed for work requiring short fast strokes. Stroke controlled by quick positioning dogs mounted on pivoted rocker connected to operating valve. Air-operated dog controlled by pushbutton on treadle changes hammer from long to short stroke. Anvil weight to ram weight ratio, 20 to 1 or 15 to 1. *Chambersburg Engineering Co., Chambersburg, Pa.*

SPECIAL GRINDER: Five-head rotary automatic surface grinder for finishing sides of connecting rods and connecting rod caps. Workpieces held in automatic clamping fixtures; one revolution of table under grinding heads finishes one side. Parts are then turned over to finish other side. Automatic sizers keep work within specified tolerances. *Mattison Machine Works, Rockford, Ill.*

BENCH WELDING HEADS: Line of low-inertia welding heads featuring Tweezer-Weld action that automatically applies correct follow-through pressure. Can handle small parts at 3600 welds per hour. Screw provides adjustment of pressure from 6 oz to 15 lb between electrodes. *Federal Tool Engineering Co., Newark, N. J.*

STAKING PRESS: Semiautomatic air-powered bench type press for light staking, forming, riveting, punching, etc. Delivers up to 60 spring-powered blows per minute with variable impacts to 12,000 lb or gives adjustable air-powered



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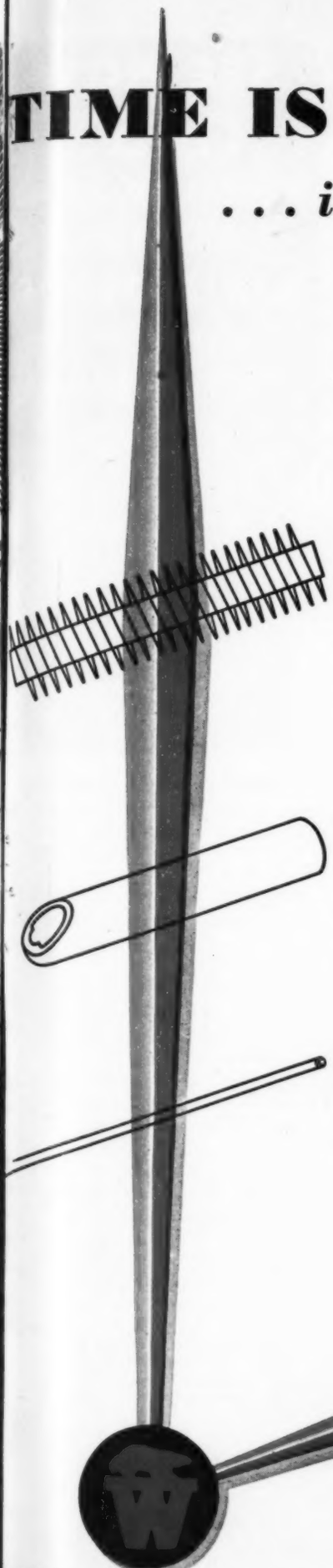
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2

SPUN END PROCESS†—is proving a great time-saver. Its use has enabled many manufacturers—often through a simple change in the design of tubular parts (components of their products)—to completely eliminate separate end closures or other assemblies and also reduce the time and cost of assembly operations.

† *Re Issue 22465*

3

CAPILATOR*—the Wolverine capillary tube used for restriction purposes—is unique in its field. Its bore is plug drawn, assuring a perfectly smooth inside surface that allows a uniform, uninterrupted flow through the tube.

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squeeze up to 12 times line pressure. Throat, 10 in.; stroke, adjustable from 1 to 2 in. Two-hand controls for manual feed; foot operation at up to 75 strokes per minute. Has 8 by 10-in. base, stands 30 in. high, weighs 72 lb. *Winter Products Inc., Bridgeport, Conn.*

SURFACE FINISHING MACHINE: For finishing both surfaces of flat or contoured parts to any degree from flash removal to mirror finish. Model 202 machine designed to provide automatic float of buffs at any preselected pressure. Equipped with two spindles to accommodate rolls 40 in. wide and up to 9-in. diameter. Automatic hydraulic in and out stroke adjustable from ⅜-in. to 24 in. *Clair Manufacturing Co., Olean, N. Y.*

TURRET LATHE: Precision toolroom lathe for fast production of small parts. Has 9-in. swing, variable cutting speeds from 90 to 3750 rpm. Draw-in collet capacity, 1⅛ in.; stationary collet capacity, ⅞-in.; Automatic indexing turret revolves on ball thrust bearings with constant preload opposed by taper roller bearing to prevent vertical error. *Rivett Lathe & Grinder Inc., Boston, Mass.*

BORING MACHINE: Precision horizontal hydraulic boring machine meets work tolerances of plus or minus 0.0003-in. Boring capacity, ⅝ to 6½ in. diameter. Portable units weigh 200 and 300 lb. Work is held stationary, only tool revolves. Spindle driven by V-belt from ½-hp motor through pulleys giving 460, 900 or 1400 rpm of tool. *Hydro-Borer Co., Inglewood, Calif.*

PUNCH PRESSES: Speedex 5-ton dial feed punch press with 1 or 2-in. stroke. Timing on index feed adjustable by rotating timing cam on crankshaft, is accurate to 0.0002-in. Index feed locks in position during press stroke. *O. F. de Castro & Associates, Los Angeles, Calif.*

BANDSAWS: Three models providing speed ranges of 80 to 5000 fpm. Blade speed changed by turning handwheel, indicator at eye level gives speed. Blade tracking arrangement places pivot point at crown of upper band wheel to hold crown in exact alignment with bottom wheel at all times. Upper band wheel assembly mounted on rigid steel tube with 4-in. vertical adjustment to give 8-in. blade take-up. Table measures 16½ by 17 in., tilts 45 degrees right and 5 degrees left. Uses flat or Tyler Spyral blades. *Tyler Manufacturing Co., Inglewood, Calif.*



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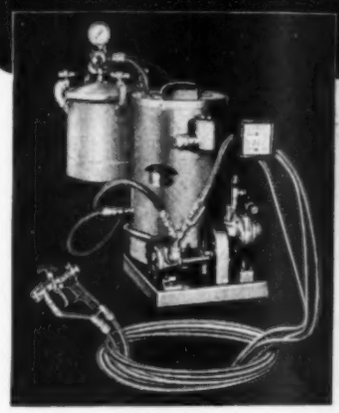
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